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High-Intensity Light Source - Proposal

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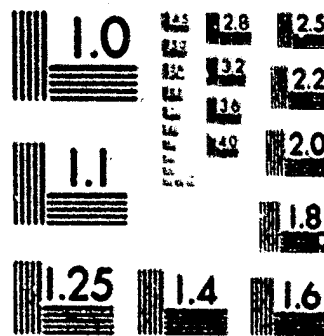
*Image Definition Device - T&E Report
(RADC Development)*

Declassification Review by NGA/DoD

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1.0 ABSTRACT

25X1 This proposal is for the development of a High Intensity Tracking Light Source for utilization with the [] 1540 Split Format Light Table. This light source is for utilization with complex high resolution optics over a limited, defined zone of the present illuminated area, with the objective of maintaining as many of the present qualities of the 1540 Split Format Light Table as possible. The mechanical constraints of installing such a light source in the table are presented along with various possibilities of light source configurations to obtain the required illumination. The advantages and problems in utilizing the various light sources within the mechanical constraints of maintaining the high quality features of the 1540 Light Table are presented. Four configurations are offered, each with a different set of cost/performance trade-offs. By presenting the designs in this manner, [] feels the Government may choose the system which most nearly meets its overall goals on the basis of various technical and cost trade-offs.

25X1 It is proposed that this effort be performed under a cost reimbursement type contract. Cost details for each of the configurations offered are given in Enclosure 2. Schedules for the various configurations are given in Section 6.0.

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2.0 INTRODUCTION

This proposal describes a program to develop a High Intensity Tracking Light Source to be installed in a Government furnished 1540 Light Table as a functional prototype. The high intensity tracking light source will provide an interpreter with the ability to view film of high density through very high resolution, complex optics.

The existing light sources on the 1540 Light Tables provide in excess of 3,000 ft. lamberts of luminance at the 15" x 40" viewing surfaces. As increasing the luminance level of such large areas creates discomfort and unnecessary expenditure of power and light, it becomes desirable to concentrate higher luminance levels into an area small enough to fill the field of the microscopes utilized and properly illuminate the numerical aperture of the objectives. The highly advanced optical systems that are developed essentially result in decreased light transmission. With a high density film or great variation in film density, the brightness apparent to the viewer becomes substantially lower than would be desirable for effective photo interpreter usage. As an example, a 2.0 density film with optics transmission of the order of 10% would result in a typical brightness of about 2 to 3 ft. lamberts under normal table illumination. An increase to 25 to 35 ft. lamberts through the microscope would provide the operator with better conditions for viewing detail using advanced optical systems.

In addition to meeting the goals of the Development Objectives for a High Intensity Tracking Light Source, the qualities and characteristics of the 1540 Light Table are to be preserved. A brief description of the 1540 Light Table is presented to review its performance characteristics.

Various concepts are described and vary from no modification to the light table, to a high degree of modification. From these, four approaches are selected. These proposed approaches are:

- An add-on viewing surface approach raising the eyepoint a small amount. This offers no modification to the light table except the mounting on the surface of the equipment necessary to operate and control the high intensity source.

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Enclosure 1

- An approach similar to the first, but with a two inch increase in the eye-point height as a trade-off for higher light intensity.
- A partially inserted package which raises the viewing surface slightly. This approach provides a maximum amount of space for the high intensity source and its controls; requires some modification to the light table; but preserves a good portion of the desirable light table characteristics.
- A completely inserted package involving no change in the height of the viewing surface. Modification of the light well is required. Most of the significant light table characteristics are preserved.

The approaches discussed in this proposal and the configurations selected are based on not only meeting the technical objectives and retaining human engineering characteristics existing in the light table, but also on the relative costs when in production. By proposing more than one approach, the various trade-offs involved may be considered in order to select a product which will provide the photo interpreter with an instrument which is not only efficient and meets the technical objectives, but is also economically feasible.

The following basic program is proposed.

1. Provide an examination and study of the particular configuration chosen relating the factors of human engineering, components, and compatibility with spaces available with the goals stated in the development objectives. This task will be closely coordinated with the Government representatives in order to achieve the optimum overall end result.
2. Present pre-design results of study and analysis for review by the customers before proceeding with the design effort.
3. Design, fabricate, and install the high intensity source in the Government furnished table.
4. Provide monthly reports on progress, final report and an instruction manual for operation and maintenance.

3.0 TECHNICAL DISCUSSION

3.1 Review of Development Objectives

It is the intent of this program to extend the versatility of the 1540 Light Table in such a manner as to provide a local intense area source for viewing areas directly under the stereomicroscope over a limited zone. This high intensity source is to complement rather than be a substitute for the existing illumination covering the total viewing area. The high intensity sources are to track the optical systems associated with the table. It is desirable to conveniently uncouple the light source tracking system from the carriage optics so that the optics carriage mount can be moved anywhere within the 15" x 40" broadly illuminated area of the light table. More detail requirements and objectives are itemized below. In all discussion that follows "light source" refers to the high intensity tracking light source except as otherwise noted.

1. The high intensity light sources shall be capable of being locked in common synchronized motion after the initial independent alignment of each light source with the objective of each rhomboid.
2. Each high intensity light source provides an illuminated area of 2-3/4" wide which may be square or rectangular.
3. Illumination level of the high intensity light sources are to provide at least 25,000 ft. lamberts maximum and a minimum of 1500 ft. lamberts for an overlap of approximately 500 ft. lamberts between the broad background illumination and the local high intensity source.
4. Illumination level from the light source is to be variable, either in one continuous range from minimum to maximum, or in two overlapping ranges.
5. Replaced broad background lighting lamps (if required) must cover a light luminance range of 200 to 2,000 ft. lamberts.
6. Color of the high intensity light sources should be broadband with a color temperature of $5000^{\circ}\text{K} \pm 500^{\circ}\text{K}$ at all luminance levels.
7. A color rendering index of 70 or higher is desirable for the high intensity sources.
8. Uniformity of the illumination from the light source should be such that the brightness gradient for each of the light sources will not exceed 20% measured at 25,000 ft. lamberts over the 8" x 15" zone of interest.

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Enclosure 1

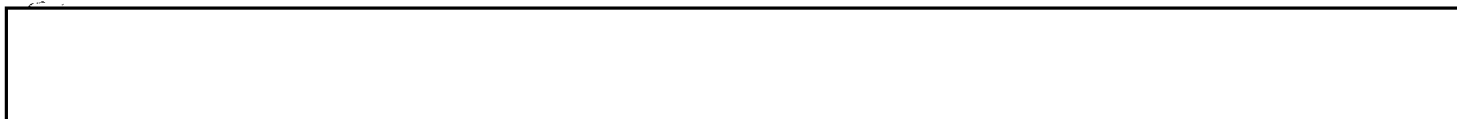
9. Heat from the high intensity light sources shall not raise the glass viewing surfaces of the table above 110°F or 30° over ambient whichever is higher when film of 2.0 density covers at least 66% of the glass viewing surface. Any attachment to the table should be such that the temperature of the glass on the attachment will not be more than 20°F above the viewing surfaces of the associated light table.
10. Controls are to be provided for independently varying the intensity of the light source - a separate ON/OFF switch is to be provided for each light source.
11. Means will be provided for independently adjusting the position of the light sources under the optics of the associated stereoscopic system. Locks must be available to maintain the positioning of these light sources when set.
12. The overall maximum dimensions of the light table shall not be exceeded under all operating conditions with the light sources and tracking mechanism installed.
13. The microscope eyepoint height should not be significantly raised. (Two inches is considered maximum allowable: less than one inch is desirable.)
14. Parallelism between the horizontal plane of the stereoscopic mount and the image viewing surfaces of the light table shall be within 15 mils over the entire translation field of the stereoscope mount. In general safety precautions must be followed for the safety of the operator.
15. Power for this equipment shall be 117 volts, 60 Hz, single phase alternating current.
16. Construction of this equipment should meet the highest commercial standards. Ease of maintenance should be an important consideration to retain the capability currently existing in the 1540 Light Table.

3.2 Review of [] 1540 Light Table

Because of the evidence that some modifications might be required to the light table, a review of the unique characteristics of the existing [] 1540 Light Table (Figure 1) is made below.

The [] 1540 Light Table is the most advanced of its type available. It is simple to operate, functional and is highly sophisticated in its performance. It may be found impossible to retain all of these characteristics in order to meet this Design Objective but the trade-offs will be such as to alter those which least effect the quality of the table.

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A-1620
30 December 1970

U. S. Government

Subject: Request for Proposal No. FIC-01-71 (50056)

Gentlemen:

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In response to the subject request, [redacted] is pleased to provide a proposal for developing a high intensity light source for introduction into the Modular Light Table as complementary illumination to the general table illumination for the viewing microscope optics. Four configurations are offered and each is discussed and priced in detail.

This proposal covers the information specified in the proposal format and is organized into two enclosures. Enclosure 1 contains the deliverable items, technical discussion, work statement, schedules and GFE for each configuration. Enclosure 2 contains the cost and financial considerations. We propose that the prospective cost reimbursement, research and development contract contain identical provisions to those incorporated in [redacted] by mutual agreement. This proposal shall remain firm for a period of sixty (60) days from the date hereof.

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However, as a substitute, we recommend a prior study investigating the various configurations and trade-offs resulting in a selection of the one configuration to be designed, fabricated and installed in the Modular Light Table. For planning purposes the estimated cost plus fixed fee for this investigation is [redacted]. This approximate amount will be further definitized if this approach is selected.

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We sincerely appreciate the opportunity of providing this proposal and look forward to discussing it with you at your earliest convenience. Please direct any questions or requests for further information to [redacted] or the undersigned.

Very truly yours,



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WGB:jwc

Enclosure: (1) Technical
(2) Financial

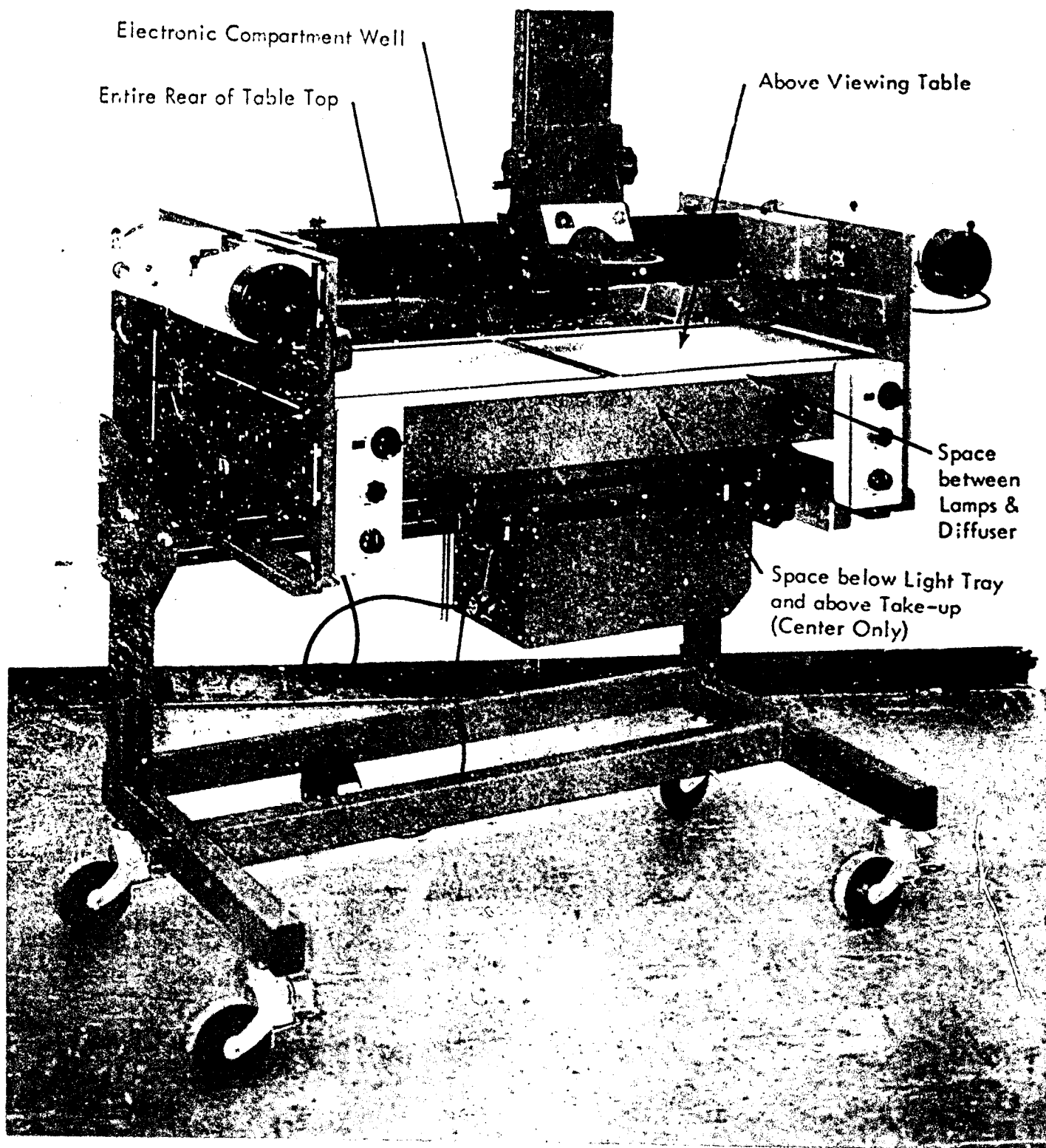
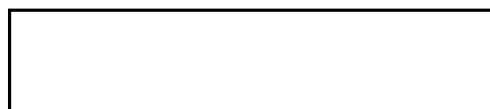
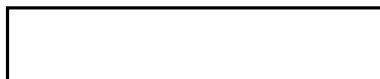


Figure 1.



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3.2.1 Table Performance and Characteristics

1. Motorized Transports

An entirely new design has produced a highly reliable motorized roll film transport system which exhibits the following characteristics:

- Two-speed ranges High speed 0 ips to 100 ips
 Low speed 0 ips to 1 ips
- Highly precise film transport controls at all speeds.
- Snap from one speed range to the other with a simple push/pull switch integral with the speed control knob.
- Powerful enough to handle 10.5" flange diameter film reels fully loaded with film. Easy to load the chamfered spindle ends on retracting hubs.
- Color coded and spring loaded reel holders for format positioning. Handles all formats - 70mm through 9" wide.
- Large segmented rollers with hard anodized and microsealed surfaces which provide smooth, dirt free long life, abrasive-free surfaces.

2. Viewing Surfaces

Two viewing surfaces, each 15" wide by 20" long, are separated by a simple top-loading takeup loop. Viewing illumination is adjustable through a 20:1 range downwards from 3,000 plus ft. lamberts. The following features will be found:

- Each viewing surface has 11, easily replaceable fluorescent lamps.
- The new lamp design provides full viewing surface illumination and allows simple plug-in replacement of lamps.
- Lamps not required when narrow-format films are being viewed are switched off, resulting in a cooler viewing surface without glare.
- Individual tube failure does not disable a whole light surface.
- Silent cooling fans draw heat away from the operator and do not introduce vibrations to interfere with high magnification viewing.

3. Optical Bridge

An X and Y motion optical bridge provides a stable motor-driven or manually-driven optical viewing instrument mount. The bridge exhibits these characteristics:

- Will accept most optical viewing instruments.
- The bridge drive is smoothly sustained at all speeds from 0 to 0.5 ips. Speeds can be preset.
- Incorporates a fail safe locking mechanism which ensures that at no time can the optics carriage move in an uncontrolled manner if the table is in the inclined viewing position.

4. Elevating Stand

An elevating stand, incorporating motorized or manual table elevation and tilt.

- Motorized lift raises and lowers viewing surfaces from 22 to 40 inches above floor level.
- Emergency hand crank provided.
- Motorized tilt from 0 to 15° incline toward operator.
- Resilient locking casters on all four wheels for easy movement and stable operation.
- Retracting power cord housing with 25 foot cord.

5. Overall Construction

Extremely conservative mechanical and electronic design combined with meticulous assembly assures long, trouble-free life for the equipment. Operator controls are strategically placed for operator convenience and have been carefully engineered to avoid interference with body movement when using the table. Ease of maintenance has been considered as an important design feature. The modular construction extends to the electronic packaging and includes many easily accessible test points for trouble shooting for removal and replacement to assure minimum equipment down time.

3.2.2 Table Areas Available for Space Consideration

Examination of Figure 1 illustrates spaces currently available for the introduction of a high intensity light source.

The photo illustrates the various regions which are available for insertion or simple addition of a high intensity source with little or no modification. These areas are:

- The region immediately below the viewing glass diffuser and above the lamps, approximately .46" high.
- The top of the viewing surface where an add-on unit can be placed or where a partial insert can be placed by modifying or removing the existing diffusing glass. Add-on height is not to exceed a significant eyepoint change, considered to be 1".
- An area below the lamps but above the take-up rollers. It does not extend beneath the 8" x 15" zone of interest without modification.
- The rear and top of the table behind the viewing area.
- An area in the electronic well approximately 2" x 2" x 6".

Other areas which may be considered require more basic changes in the light table construction.

3.3 Light Table Physical Constraints and Limitations

The detailed knowledge of the space and areas which are most suitable for application to the proposed development with a minimum sacrifice of overall performance of the light table are well known to Constraints which exist in the table to any auxilliary equipments that may be added are discussed and referenced to the following photographs.

Figure 2 illustrates the light table from the front in its position without the covers normally used as protective devices. The following constraints are indicated:

- The height of the microscope mount which clears the table top by 2". There is no simple means available to raise this without significantly altering design and fabrication.
- The cross beam channel which moves forward and back. It is within 3/8" of the rear supporting cross member in its rearmost position.
- The gear train on the right side of the table which overlaps the viewing area by 1.5" from the rear at the right hand corner.

Figure 3 provides a rear view and shows in more detail further space constraints as follows:

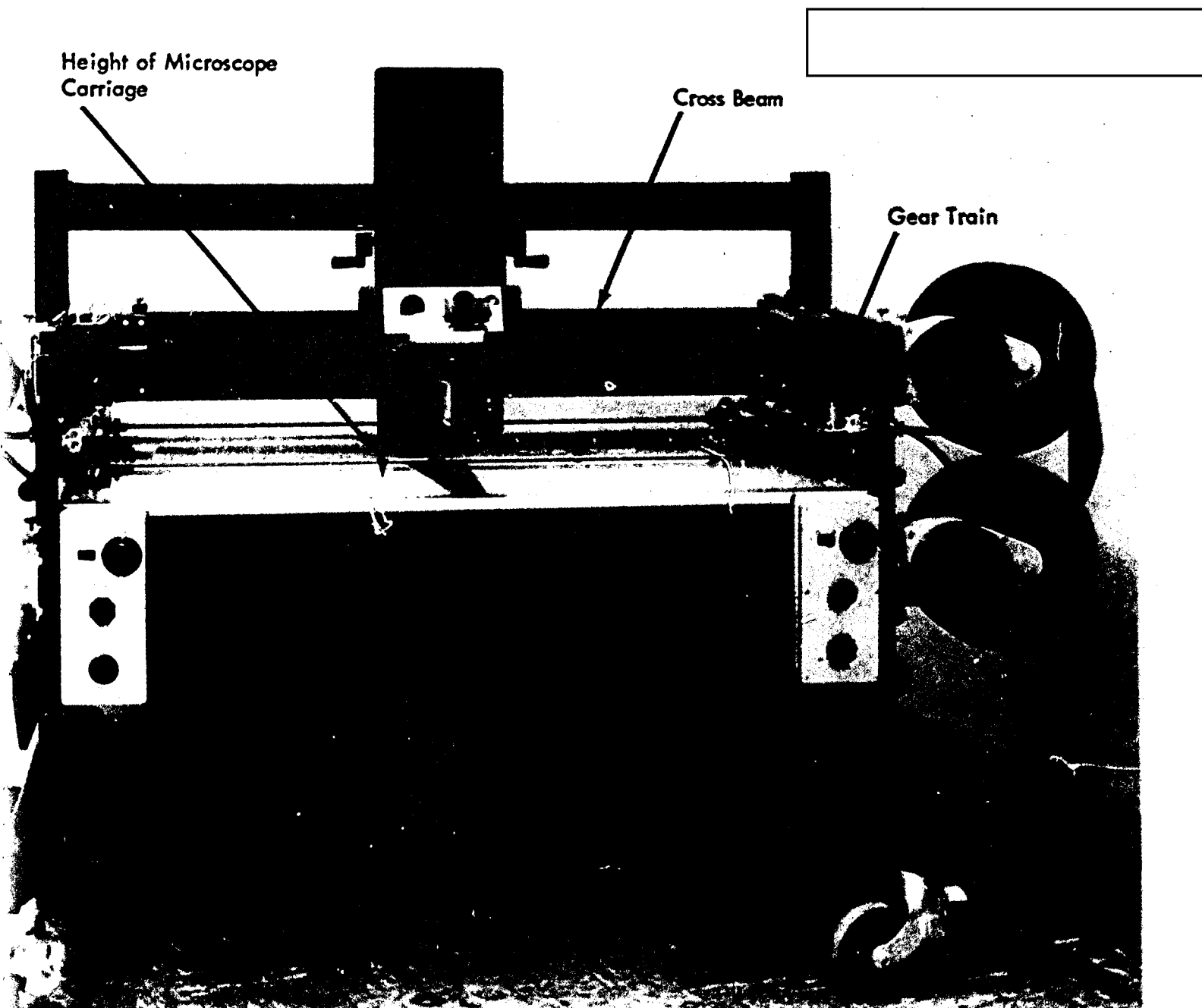


Figure 2 Table Constraints, Front

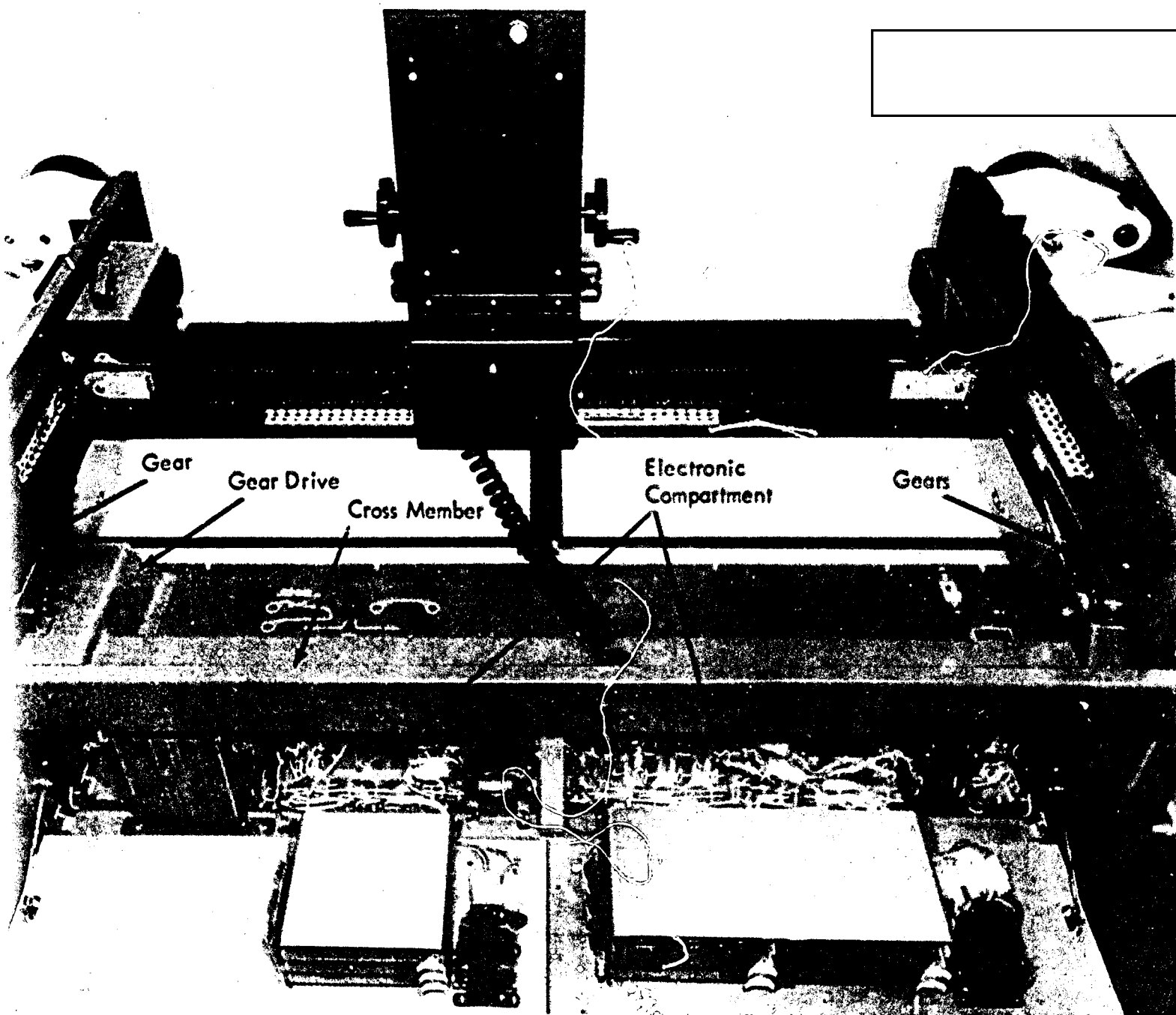


Figure 3. Table Constraints, Rear

- The gears on the right and left side of the table which restrict threading and raising the film above present viewing level.
- The hood that covers the gear train on the right side of the table as viewed from the front.
- The cross member which reaches across the back of the elevating stand.
- The electronic compartment shown are transformers, electronic circuitry and the circuit boards which come to within .5" of the mode multi switch.

Figure 4 is the view of the light tray well. Shown are:

- The slot on the left side through which the film must be threaded. When an add-on box is placed on the viewing table the film which normally comes horizontal to the viewing surface must now come down from an increased height and clear this edge.
- The farthest distance down that is permissible before interference occurs with the idling roller for the take-up beneath the table. The light package cannot go lower than this surface. In this same area the track of the take-up roller is shown as it drops below the static idling roller under the table.
- The cut in the chassis frame which accomodates the steel band that drives the take-up roller. It is a major modification to alter this slot.
- The open vent which is designed to permit air flow through the electronic package and the lamps in order to maintain temperature at the specified level for performance.

A review of Figures 2 and 4 will show that there is a limiting slot through which the film must pass to get to the supply and take up reels. In the take up area beneath the table, the film must be threaded through the rollers in the center of the table. These rollers come above the top of the table surface enabling the operator to conveniently thread this portion of the table. Increasing the height of the viewing section interferes both with this section of the threading area and could conceivably interfere with the slot leading to the supply reels at each end of the table unless rollers are added.

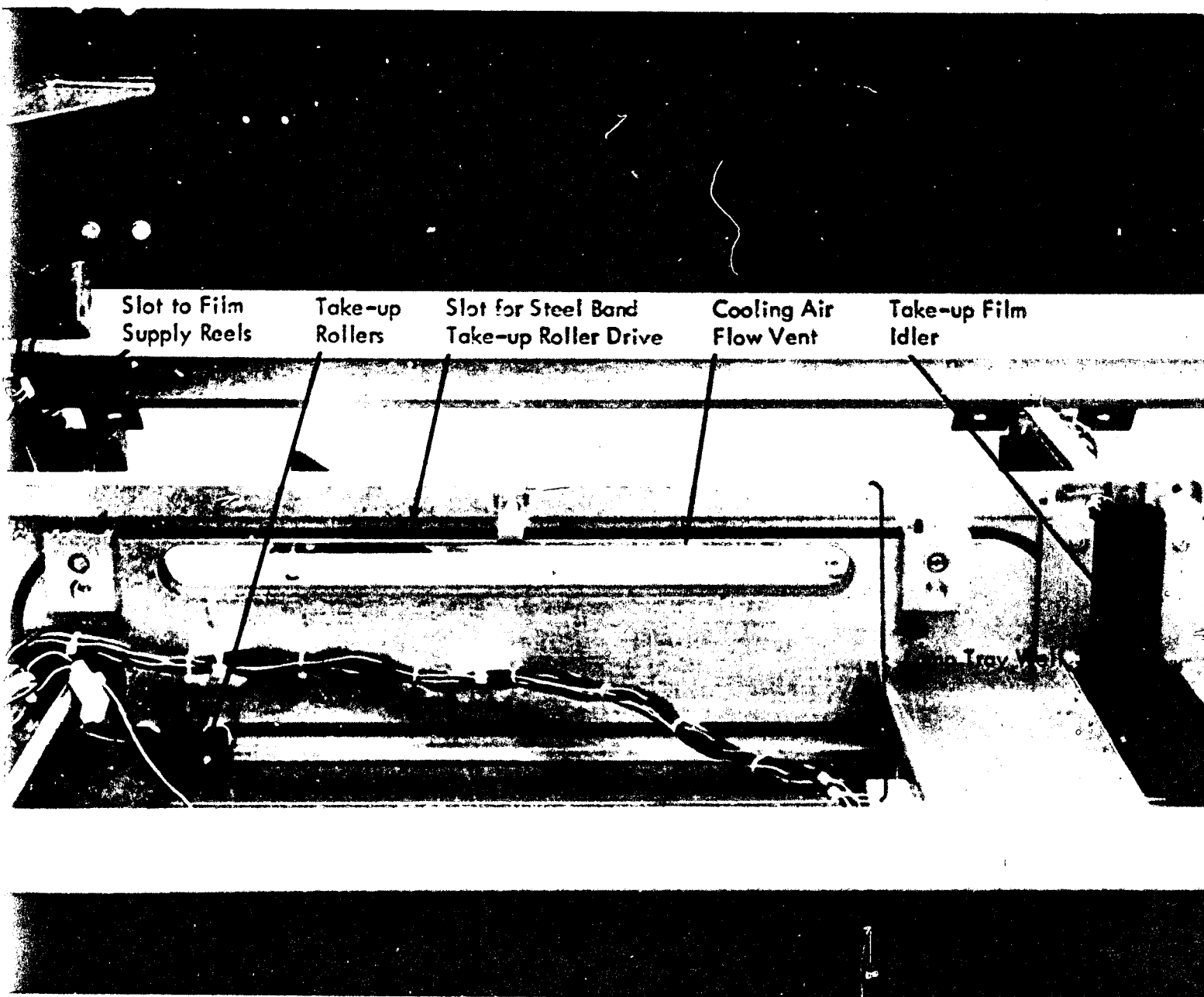


Figure 4. Table Constraints, Light Tray Well

- The track and guide for the take up roller.
- The board for the lamp terminals which lies immediately beneath the 8" x 15" zone of interest.
- Space available beneath the lamps and to the right of the 8" zone of interest.

With the present cooling requirement it was possible to utilize quiet motors and fans so that there is undetectable noise and vibration to interfere with the use of the microscope at high magnifications. The power used currently under normal operation is approximately 3 to 4 amps at 110-115 volts. However under certain conditions of operation as much as 17 amps could be drawn. Thus, separate input power wiring will be required for the added light source.

Figure 6 indicates the dimensions of the existing light tray with possible modification. Shown is the existing position of the viewing glass, the space available above the lamps, and with the viewing glass raised 1" above the table top. Also shown is the distance required at the end of the table so that the film will clear the slot to the supply spools. To achieve this increase of working space above the lamps, the existing viewing glass must be removed and raised to the new position. The height of the eye-point is raised by the same amount, i.e., approximately 1" which is considered within the tolerance of a significant height change.

3.4 Human Engineering Considerations

To add to the table physical constraints and limitations there are the human engineering considerations. One such consideration is the eyepoint height which was discussed in the preceding paragraphs. Other primary human engineering areas to be considered are as follows:

- Beneath the table there is clearance such that the table can be dropped to the lap of a seated operator without interference with his knees and legs. This space must be retained.

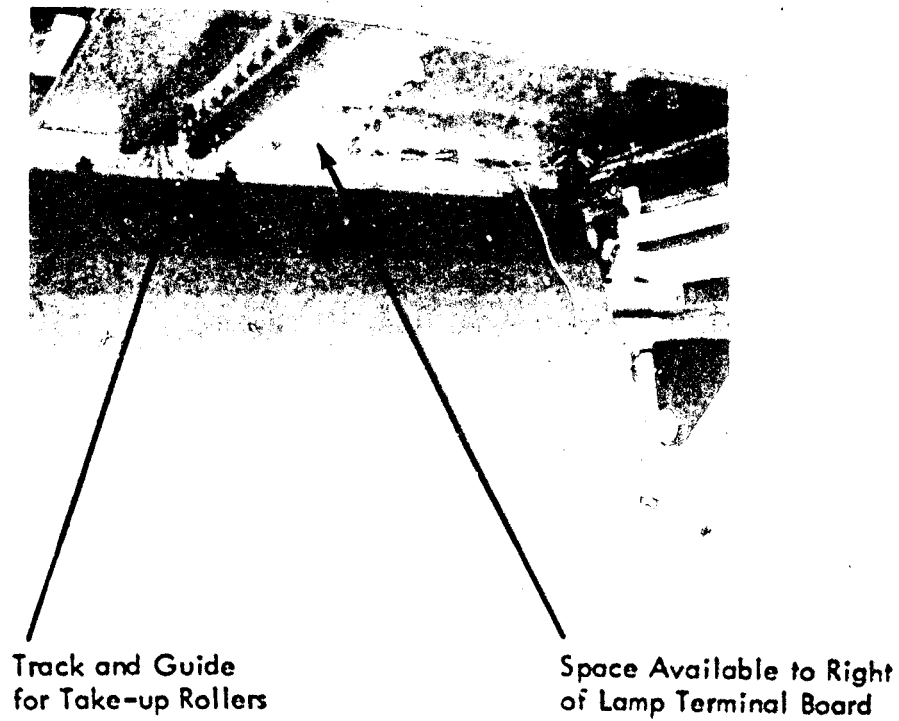


Figure 5. Table Constraints (Under Table)

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The disclosure of proposal data is subject to the restriction on the Title page of this Proposal. (DEC, 1966)

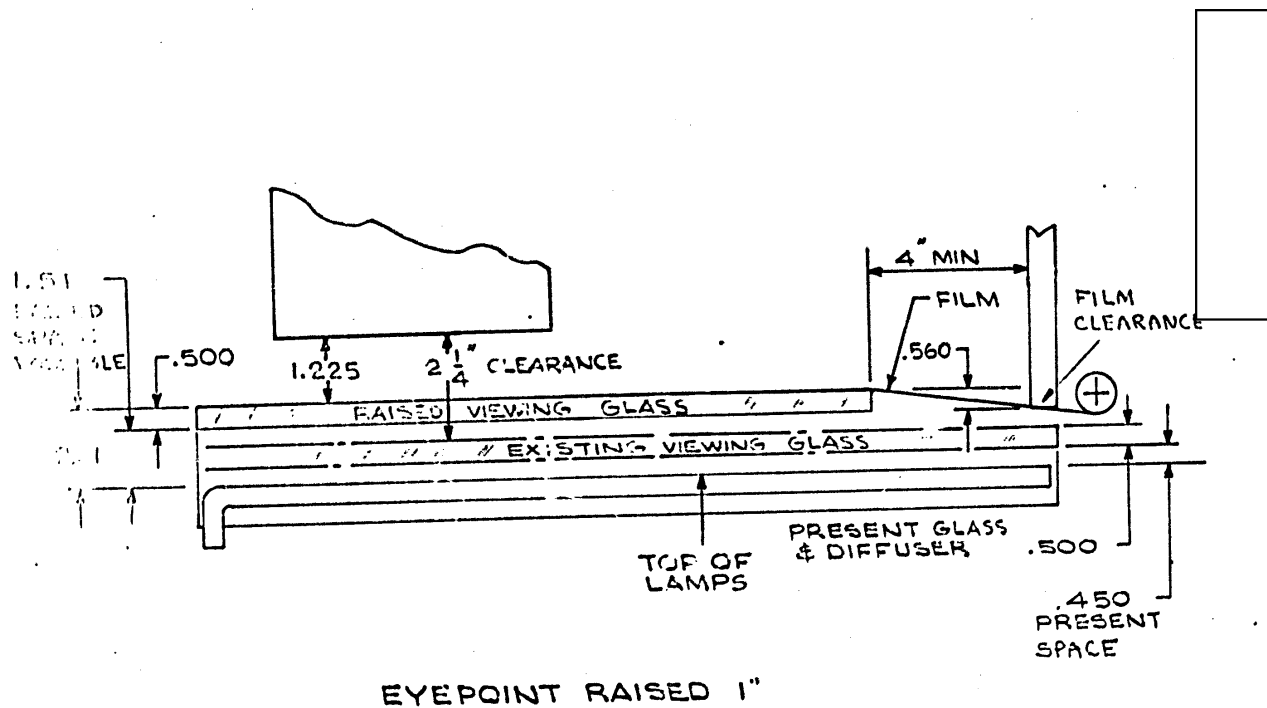


Figure 6. HEIGHT DIMENSIONS IN LIGHT TRAY

- The high general luminance of the table of 3000+ ft. lamberts plus the the electronic and motor controls requires a generous amount of air supply to be circulated. Vents have been made available for this purpose to get most efficient flow of air. Increasing heat in this area would require removal of the added heat in a direction other than towards the operator, with fans which must be kept silent and vibration free.
- An operational constraint which is properly placed in the human engineering category is the present smooth low velocity transport motion. It permits the observer to use the microscope directly in conjunction with film movement for continuous visual tracking. This is an important aid and a characteristic of the table. A change in the threading method or modification to the threading loop must be examined carefully to make sure that this is not disturbed. Examples of the areas of concern have been illustrated in Figures 2 through 6.

3.5 Component Constraints

The basic components required to implement a high intensity tracking light source are the light source itself, an optical system required to provide the high intensity illumination in the desired local area, and a means of providing tracking between light source and the microscope rhomboid objectives. Considerations and constraints in the application of available components are discussed in the following paragraphs.

3.5.1 Light Sources

A major component which establishes much of what can be done under this development is the type of lamp used for the high intensity illumination. Some of the lamps to be considered are tungsten halogen, fluorescent, and the arcs such as the Marc 300 or the Xenon arc. Various commercial lamps are shown in Figure 7.

The major consideration here is that these lamps provide the color temperature specified, have a color index of 70, and provide the illumination level corresponding to the optics utilized so that an output of 25,000 ft. lamberts will be available over a 2-3/4" x 2-3/4" area. Typical tungsten color temperature which will provide any significant amount of life is about 3250°K. To alter the color temperature to 5000°K a filter is required. An SOA light balancing filter is typical with a .27, or approximately

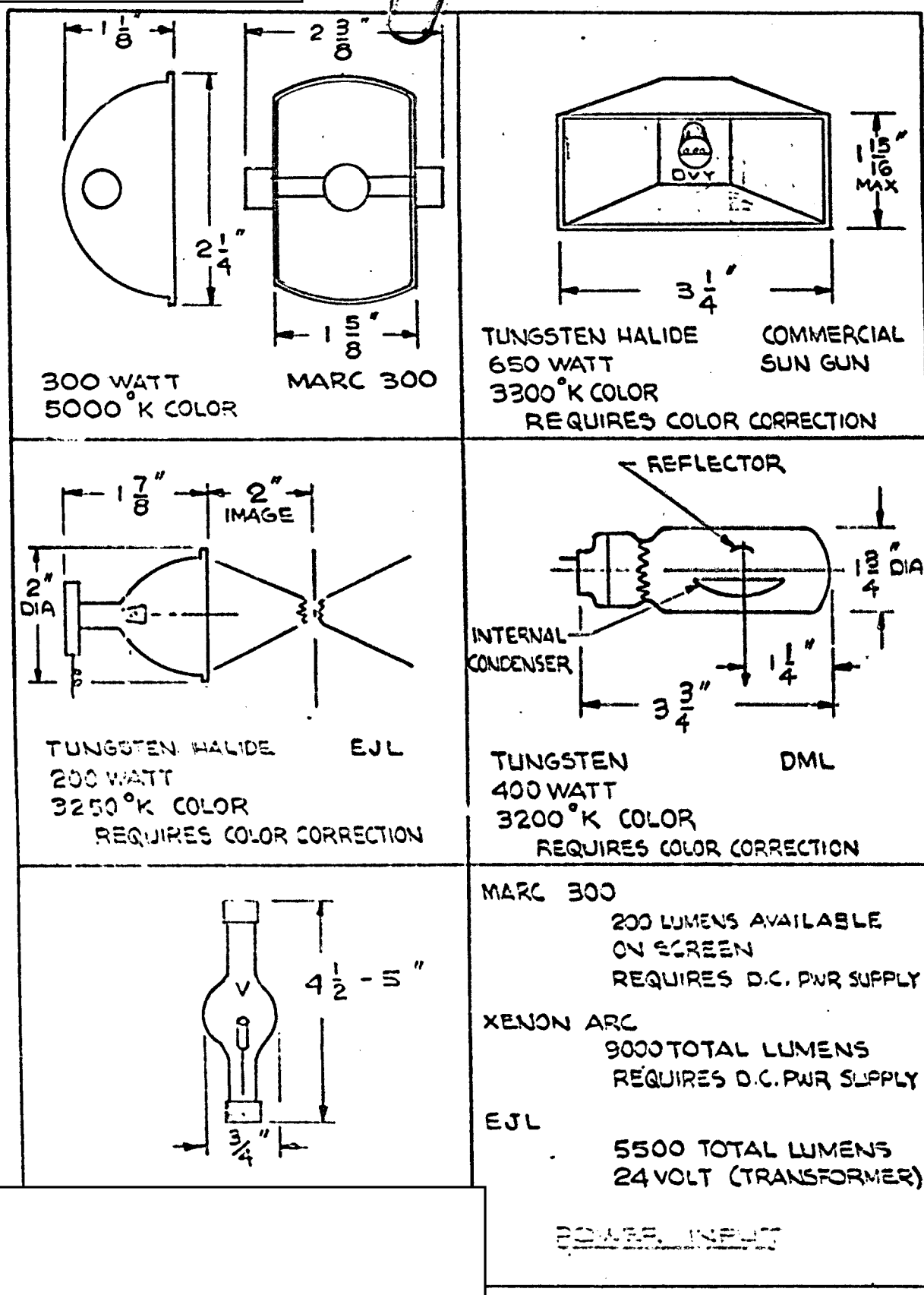


FIG 7. LIGHT SOURCES

a factor of 3, loss in the initial light from a 3250°K source. An experimental check made with a substitute blue filter typically used to change from 3200°K to 5000°K $\pm$ 500°K color temperature; photography reduced the light down by a factor of 2-1/3. On this basis one can expect that an uncorrected 3250°K tungsten must provide at least 2.3 times more luminance than an uncorrected 5000°K.

Tungsten lamps can generate about 26 lumens - 28 lumens/watt input. The Marc 300 (300 watt) arc is reported to provide 2000 lumens onto a screen through a projector and open gate. Xenon arcs provide about 26 to 30 lumens/watt from 300 to 450 watt lamps. Excluding possibilities of increasing output by lamp modification, or modified operation from standard, the total available lumens for normal watts input to each lamp are:

Tungsten	18,000 lumens	@	3250°K (correction needed)
Marc 300 arc	30,000 lumens	@	5000°K
Xenon arc	20,000 lumens	@	5000°K

With about 10% collection in projection, it is possible that 1,800, 3,000, and 2,000 lumens respectively would be incident at a light pack (see Section 3.5.2). Tungsten would require a color filter which reduces the light by at least 2x - so the list at input would be the following at the 5000°K color temperature.

Tungsten	900 lumens at input
Marc 300 arc	3000 lumens
Xenon arc	2000 lumens

For a lossless lambertian diffuser light pack, 25,000 ft. lamberts means 25,000 lumens/sq. ft. or about 1350 lumens at 5000°K must be incident in the local high intensity area.

The Marc 300 is a lamp of 5000°K color temperature initially. Thus its lumens are effective and no filter needs to be introduced to adapt it to the color temperature specification. This is also true of the Xenon arc which has approximately the same color

temperature. Fluorescent lamps can achieve the color temperature required as do the lamps currently used in the ☐ light table. However, their contribution to localized illumination is inadequate for this purpose and are excluded from further consideration.

The choice of lamps depends upon how the optics are used. Tungsten contributes a considerable amount of heat at its color temperature. The Marc 300 is much more efficient with a reported 100 lumens/watt output as opposed to approximately 26 to 28 lumens/watt output from tungsten. The Marc 300 is a small arc, it is highly suitable for projection although it usually has an aspheric reflector which is designed principally for 16mm projectors. In order to obtain a uniform illumination as specified for the high intensity projection it is essential to examine the suitability of this reflector to fit the purpose as necessary. This also applies to the Xenon arc which offers a higher possibility for projecting a beam and illuminating the area more effectively at a distance. Increasing the distance between the lighted area of the light pack immediately beneath the film and the lamp is desirable in order to permit easier dissipation of the heat from the vicinity of the film and the operator. On this basis the Marc 300 is considered the prime contender for this application. A suitable tungsten can be found and, if placed in the immediate proximity of the light pack, assuming heat is removable, a high brightness level can be achieved in spite of the color temperature change. One such lamp is the EKL 200 watt lamp with its own reflecting envelope.

The lamps supply illumination which is to be controlled over a dynamic range of 16 to 1. Means of accomplishing the control at this point are limited to mechanical or optical methods only. Tungsten for example will vary in color with voltage change. Availability of space, size and form of the beam may limit the means chosen. In a projection system an iris diaphragm placed at the aperture stop is suitable. A range of 16 to 1 corresponds to the equivalent of four stops or from 1" diameter, as an example, to 1/4" diameter. Because it is a physical method, color temperature is not altered. Control of the arc by power input change needs to be examined further.

In instances where strongly divergent or convergent aspheric beams are encountered from a collector and the aperture stop is not clearly defined, either an absorbing neutral density wedge or a variable reflecting wedge can be introduced in the position near to the smallest beam cross-section. Absorbing neutral density wedges must resist the localized heat. A reflecting beamsplitter wedge on the other hand, divides the radiation including a large portion of the heat. It is a useful approach to the application where the lamp is close to an integral light pack source.

Mechanical blinds or perforated metal are also possible but require more space and introduce non-uniformity where aspheric light collectors are employed.

3.5.2 Light Packs

Some means of directing the illumination from the lamp to the scanning area is essential if the lamp is not an integral part of the high intense viewing area. It is conceivable that the lamp itself can be placed in proximity to the bright viewing area except that it contributes to the heat existing in the light table and there is danger of raising the temperature to the extent that it could damage film or be uncomfortable to the operator. Removal of the excess heat can be achieved except it must be done in the intense localized area and it must be done with increased circulation of air requiring heavier blower motors thereby contributing to vibration, noise, and dissipation of heat either in the vicinity of the operator or over the existing electronic compartment. It is therefore considered advisable to place the lamp itself where the major portion of the heat can be dissipated conveniently.

This is an advantage of a scanning block or light pack which redistributes the light beneath the film at the rhomboid area. However, it produces constraints in the design for the following reasons:

- . Has weight
- . Must be moved about in the zone of interest.
- . Must be made to collect light in one aperture that is very confined and spread it over a much larger area beneath the objective of the rhomboid.
- . Requires projection optics which take up space.

Approaches to accomplish this consist of light packs at the high intensity area. Several light pack concepts are illustrated in Figure 8 and are discussed in the following paragraphs.

(Fig. 8a)- A light pack collects the incident light and directs it in the proper direction. One light guide pack is illustrated in Figure 8a. It consists of flat sheets of plastic or glass with a slight taper towards the large area in such a manner that the incident light remains totally internally reflected and its output is in the large area in the near vertical direction. It has a large length to width aspect at the input. A diffuser with some gain is inserted at the top to distribute the light uniformly. Although packaging losses are low the aspect ratio with 2-3/4" length makes it awkward for folding the optical beam in confined spaces. This pack offers low transmission loss.

(Fig. 8b) Another light pack concept, exceedingly simple and quite suitable, is the use of a barium sulfate diffuse reflector with a large length to width aspect ratio at the input as shown in Figure 8b. Barium sulfate has a very high degree of lambertian scattering characteristic and it has in excess of .95 reflection. It therefore is capable of taking a beam of light that strikes it at a high angle of incidence and diffusing it over a hemisphere to provide uniform brightness. For example to obtain 25,000 ft. lamberts output with the incident beam at 60° 50,000 ft. candles incident over the total input area is needed. This concept offers free air circulation and low cost.

Measurements taken of luminance values when light is incident normally and at 60° show dependence on the cosine. The objectives of these light packs as stated earlier is to permit the input end to be shaped to fit within the confined height above the viewing area of the light table. In order to be utilized effectively, a matched projected beam must have a reasonably uniform cross section from the rear of the viewing table to the front over a distance of approximately 12". This calls for a high degree of collimation and a matching of the lamp properties with its reflector to the projecting lens.

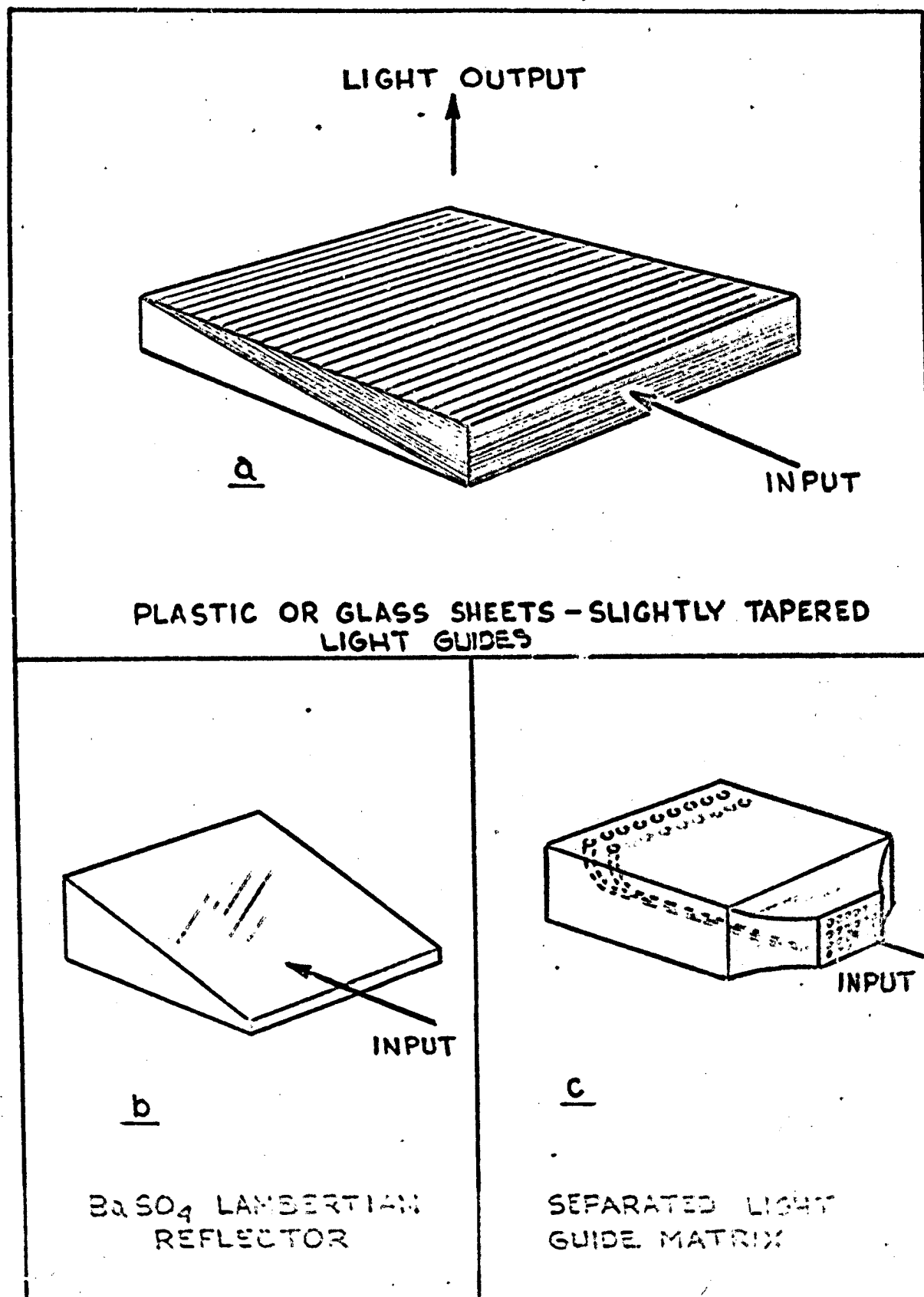


FIG. 3 a, b, c LIGHT PACKS

This or disclosure of present data is subject to the re-
striction on the Title page of this Proposal. (DEC. 1966)

(Fig. 8c) Figure 8c illustrates the use of circular light guides. These could be placed in an array or matrix 1/16th of an inch apart at the top and brought together into a compact area of approximately 3/4 to 1 inch diameter where the light is projected and concentrated. Figure 9 is a pair of photos of experimental tests showing the light guide output for a 5x5 matrix placed 0.10" apart. Figure 9a shows the diffuser in contact with the output. Figure 9b shows the increased uniformity as the diffuser is placed 0.6" away.

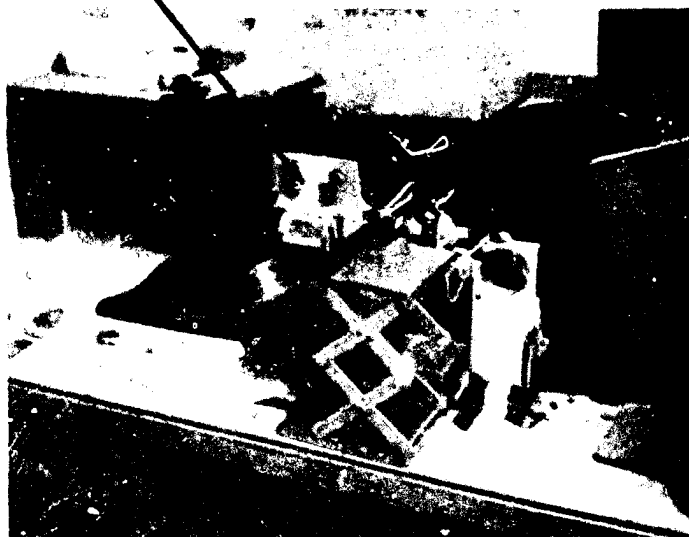
Circular light guides compared to flat guides, have a packing density which reduces transmission to about 0.7 at best with 0.6 total being more realistic. However circular light guides can be arranged into unusual shapes so that the input aspect ratio can be made 1.0 and can be a compact circle which permits the symmetrical projected beam to be bent in any direction with equal ease.

Experiments were conducted so that packing density was included in the light guide pack measurements with a sample 5x5 output matrix of light pipes .040" diameter spaced 10" apart plus a high gain diffuser at the output. It was determined that 3500 ft. candle incident over the compacted 25 pipes (5x5 output matrix) would produce 340 ft. lamberts axially at a ratio of 10 ft. candles incident for each ft. lambert output. If the light guides are reduced to .020" diameter plastic, the output would be reduced to $\frac{.020}{.040}^2$. On the other hand increasing the number of pipes by reducing spacing of the output to .050" would increase the output by $\frac{0.10}{0.05}^2$ resulting in the same output brightness level since both changes are area dependent. Hence at 25,000 ft. lamberts output, 250,000 ft. candles are required at input over 1" diameter or 0.78 square inches for a total of 1360 lumens of 5000°K color.

The particular significant constraints and considerations established by the utilization of 2-3/4 inch light packs are:

- Contribution to shadowing of the general illumination from below.
- Mechanical orientations in the X and Y direction.
- Mass

Diffuser Output in
Contact with Light Guides



Diffuser Spaced away
from Light Guide

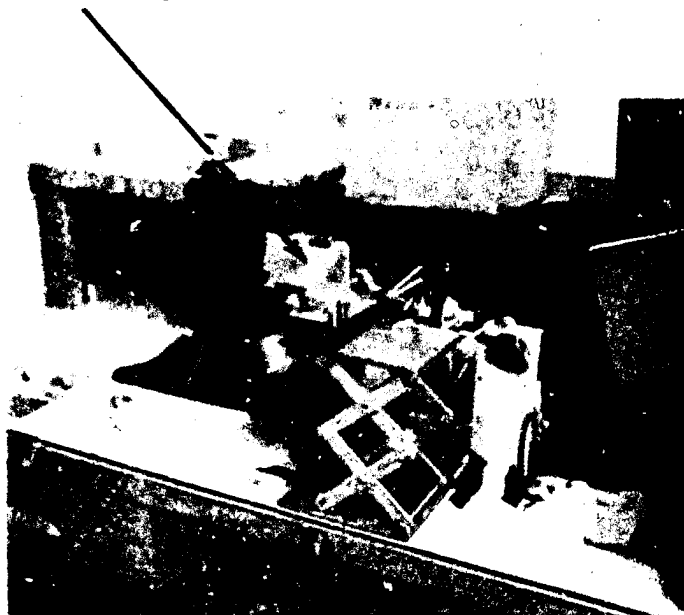


Figure 9. Light Pack - Pipes Experiment

This is disclosure of personal data is subject to the restriction on the title page of this proposal. (DLC 1960)

- A physical dimension limiting their placement when not in use.
- Use with the light source at a distance to control heating.

Application to a given configuration requires some concept and design study for compatibility with the shape of light beam required.

3.5.3 Tracking Mechanisms and Linkage Concepts

Several methods of linking the high intensity source to the carriage movement for tracking of the rhomboid objectives are available. Final choice of a method depends upon the lamp and the optics chosen, as well as the method of implementation in the light table. That is, whether the high intensity source is to be implemented as an add-on unit or as a unit integrally contained within the table. The following paragraphs discuss various methods which might be utilized as a part of an overall design.

3.5.3.1 Direct Drive - Mechanical gearing and drive shafts which permit the microscope carriage to move in X and Y direction over the viewing table can be used directly to control the high intensity source. A drive shaft across the rear of the table can be linked to provide the mechanical movement of the added source in the Y direction. The X tracking is more difficult and may require a cable to transfer the linear X movement of the carriage to the source. This approach is simplest to introduce for an add-on concept.

Two points of concern are:

- Light obscuration
- Loading on the present sensitive and smooth movement of the microscope carriage.

A recessed or insert type of light source package requires reworking the structure of the table to pass either cables, straps or shafts. The direct mechanical method is particularly inflexible to good human engineering and placement of the controls for the operator.

3.5.3.2 Servo-Coupled Systems - An electro-mechanically coupled servo system offers flexibility and is more versatile. It can be applied to any type of high intensity configuration concept.

In this system the position of the microscope carriage is detected by a position transducer attached to the X drive at the rear of the cross bridge and another for the Y attached to the side of the table. These transducers may be potentiometers, synchros, or other suitable position detectors. Similar position transducers are attached to the light intensity sources and scaled in accordance with their position relative to the microscope carriage position. A means of offset such as a bias potentiometer or synchro differential is introduced in each of the two high intensity source drive channels so as to allow initial positioning of the source beneath the microscope rhomboid objectives. Differences in the appropriate transducers position are determined electrically and amplified by appropriate servo amplifiers to drive motors for positioning the high intensity sources. Disengaging of the drive system when the high intensity sources are not in use is easily accomplished electrically.

3.5.3.3 Linkage and Support - Cables can be used to link the drive motors or shafts to the light pack. In some configurations the light pack could ride directly on a clear glass or diffuse surface using teflon balls attached to the light pack to minimize friction. Unidirectional negating coil springs would eliminate a complete loop to minimize shadows at the viewing surface.

An air bearing approach may be practical. In this case the light pack emits air at the bottom to provide a cushion between itself and the glass plate. This technique is highly valuable if the light pack is magnetically or photometrically linked to a suitable sensor at the rhomboids.

25X1 has had considerable experience in air cushion operation to transport film over large film gates and around rollers without touching.

From cost viewpoint the cable-pulley linkage may be most practical, unless it introduces a significant interference with performance and operation of the light pack.

3.6 Design Approaches

The number of combinations between space available, various constraints on components and table performance result in many possible design approaches. Fundamentally the light must be examined in accordance with its proximity to the film where heat will easily buckle the film as a new area is viewed and require refocusing of the microscope. To hold the eyepoint close to the present position, a light source having a high luminous efficiency at the required color temperature must be placed at a reasonable distance from the local intense viewing area. This suggests some form of projection.

The limited space available in the direction perpendicular to the table between the lamps and the viewing glass results in an awkward aspect ratio of the projected beam cross section. Thus sophisticated means of projection as well as collection at the light pack under the viewing area is essential. With some constraint relief, such as an increase in eyepoint height, use of a lamp with lower power and heat characteristics could achieve the high intensity illumination. Increasing eyepoint height increases light pack collecting area.

Intensity level or dimming of the light source may of necessity be minimal. Control at an aperture stop is desirable for best control and minimum size and is suitable for projection techniques. Mechanical shutters over a large beam are inefficient and too complex and nonuniform.

The following paragraphs describe various design approaches which may be implemented in providing a high intensity tracking light source. The advantages and disadvantages of the various approaches are discussed, and, as will be seen, some are concluded to be either technically undesirable or economically unfeasible.

A-1620
Enclosure 1**3.6.1 Existing Space Utilization - Integral Light Pack**

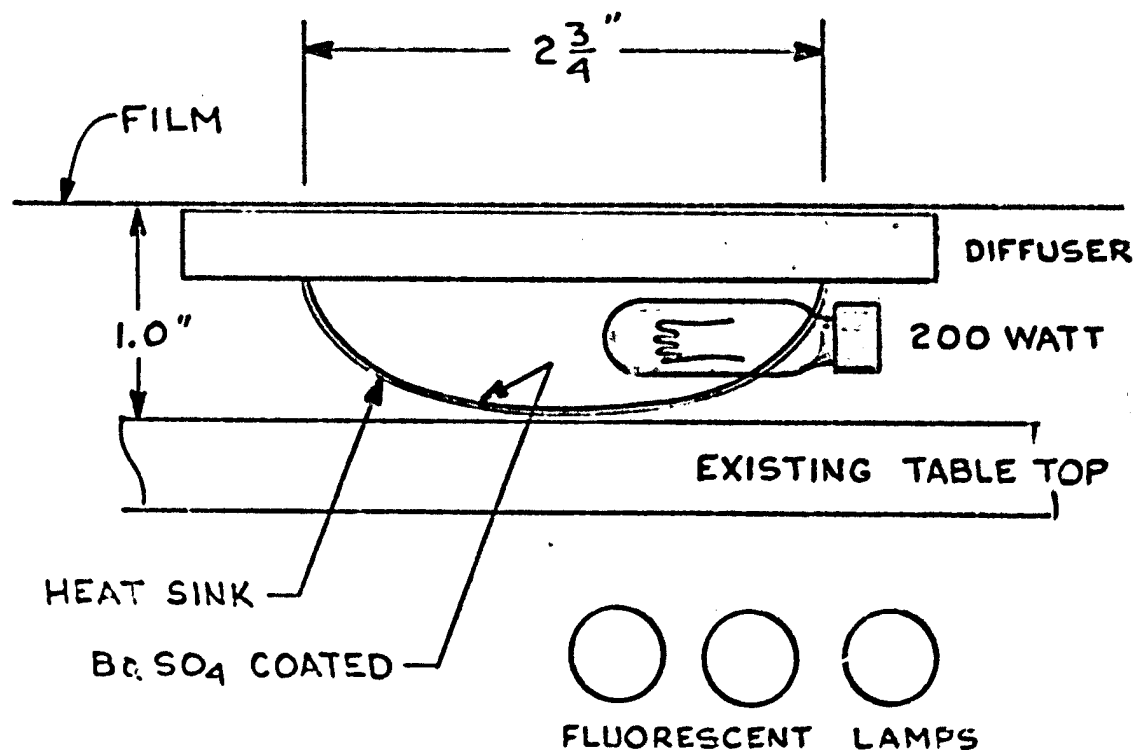
Consider the 2-3/4 inch square region consisting of an integral light source containing a lamp mounted immediately below the present viewing glass (Figure 10). There is 0.46" height available. Any lamp having sufficient lumens output to be utilized in this space will be within 0.060" of the surface.

Difficulties are:

- Obtaining uniform distribution of light over the 2-3/4 inch area.
- Controlling dimming since
 - a. An arc normally does not have the range of control
 - b. Tungsten changes color temperature if current control is used.
 - c. Physical dimming creates non-uniformities because of proximity to the film region.
 - d. Neutral density wedge would be enormous
 - e. Crossed polarizers cut the light to 1/4 at maximum transmission.
- Technical and human engineering considerations of:
 - a. The heat generated in addition to existing level could buckle the film and also produces more heat to the operator. Heat generated would require high velocity movement of air, but the glass top with diffuser is a poor heat sink to permit effective control of temperature.
 - b. Concentrated air flow requires added air pump raising the vibration which could easily be transmitted to the film in this type of package.
 - c. Heat would be dissipated through a duct over the background light, or over the electronics where it is undesirable, or toward the operator.
 - d. Added ducts or fins obstruct the background.

Calculations indicated that with collection losses, plus color temperature conversion the required proximity of the tungsten lamp requires too much power to make it a practical approach even if it were an add-on device raising the film. This approach offers simplicity if an add-on, low relative cost in table modification, ease of removal and field retrofit, but must raise eyepoint to the maximum if it is to be considered. It

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POTENTIAL ADD-ON CONCEPT

FIG. 10 INTEGRAL LIGHT PACK

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does raise the eyepoint significantly, introduces vibrations and heat effects on microscope viewing, obstructs background lighting by air ducts and tracking control devices. This approach is very questionable.

3.6.2 Add-on - Projected Light

A 2-3/4 inch square can be placed on top of the present viewing table top. A maximum height of 2.0 inches will clear the microscope carriage but raises the eyepoint a significant 2.0 inches. By projecting a beam from a source at the rear of the table some of the objections to the above are eliminated.

The type of light pack used will be controlled by allowable eyepoint height which may need to be traded off with other interferences.

The add-on package permits use of mechanical linkage with the existing X,Y microscope carriage drive as well as possible electro-mechanical servo system. However it does interfere seriously with existing table top functions.

- . Extra rollers may be needed
- . Eyepoint is raised
- . Viewing area may be limited
- . Light pack is unprotected.

A projected beam however will probably require a very high intense lamp of 5000°K color temperature. An example for a projection system for 1" beam diameter plus the Marc 300 lamp is given based on measured output of the lamp. At a distance of 14" from the lamp the luminance of a white blotter was measured to be 30,000 ft. lamberts average. Normally the value of output lumens from the Marc 300 is given as 2,000 lumens minimum open gate on a screen with a 2" f/1.4 lens, 16mm aperture. However, the luminance of the .14 square inch image projected by the arc is calculated from the measured value and then total lumens available are compared for verification.

The illumination E is given on axis as

$$E = N\omega$$

where

N = luminance of source

ω = solid angle subtended by source at distance D where E (illumination) was measured.

A = area of source or source image.

thus

$$\omega = \frac{A}{D^2}$$

then

$$N = \frac{D^2 E}{A}$$

numerical substitution is as follows from 30,000 ft. lamberts measurement

$$E = 30,000 \text{ lumens/sq.ft.} = 210 \text{ lumens/sq.in.}$$

$$D^2 = 14^2 = 196 \text{ sq.in.}$$

$$A = 0.14 \text{ sq.in.}$$

hence

$$N = \frac{196 \times 210 \text{ lumens/sq.in.}}{.14} = \frac{4.1 \times 10^4}{.14} = 2.9 \times 10^5 \text{ cdles/sq.in.}$$

The projection distance for this reference conceptual system requires a 1" beam diameter with light guide pack with symmetrical input over 12" Y movement of the pack.

Consider an illuminated aperture of 0.38" square (.38² = .14 sq. inches) at 2.9×10^5 cdles/sq.in. to be magnified to 1" diameter at 12". This is approximately 3x magnification. For projection distance of 12" the f.l. of the lens becomes

$$\text{Proj Dist} = \text{f.l.} (M+1) \quad \text{or} \quad \text{f.l.} = \frac{\text{Proj Dist}}{M+1}$$

numerically

$$\text{f.l.} = \frac{12}{3+1} = 3"$$

The 1" diameter beam requires a 1" diameter lens, so the $f^\# = 3"/1"$ or $f/3$ for the aperture ratio. This system projects a 1" beam up to 12" away and the total lumens incident at the light guide pack is determined from the incident illumination, E .

$$E = \frac{\pi B T}{4(f^\#)^2 (M+1)^2} \text{ lumens/sq.in.}$$

$T = 0.8$ transmission of optics excluding light pack

Numerical substitution yields

$$E = \frac{3.14 \times 2.9 \times 10^5}{4 \times 3^2 \times (4)^2} = \frac{7.3 \times 10^5}{5.76 \times 10^2} = 1.25 \times 10^3 \text{ lumens/sq.in.}$$

It was determined earlier that 1360 lumens are necessary in the 1" diameter (0.78 sq.in.) light guide pack input to produce 25,000 ft. lamberts on a high gain diffuser. With 1.25×10^3 lumens/sq.in. incident there are $1.25 \times 10^3 \times 0.78$ sq.in. = 980 lumens collected by the pack and the lambertian output luminance would be $980/1360 \times 25,000 = 18,000$ ft. lamberts

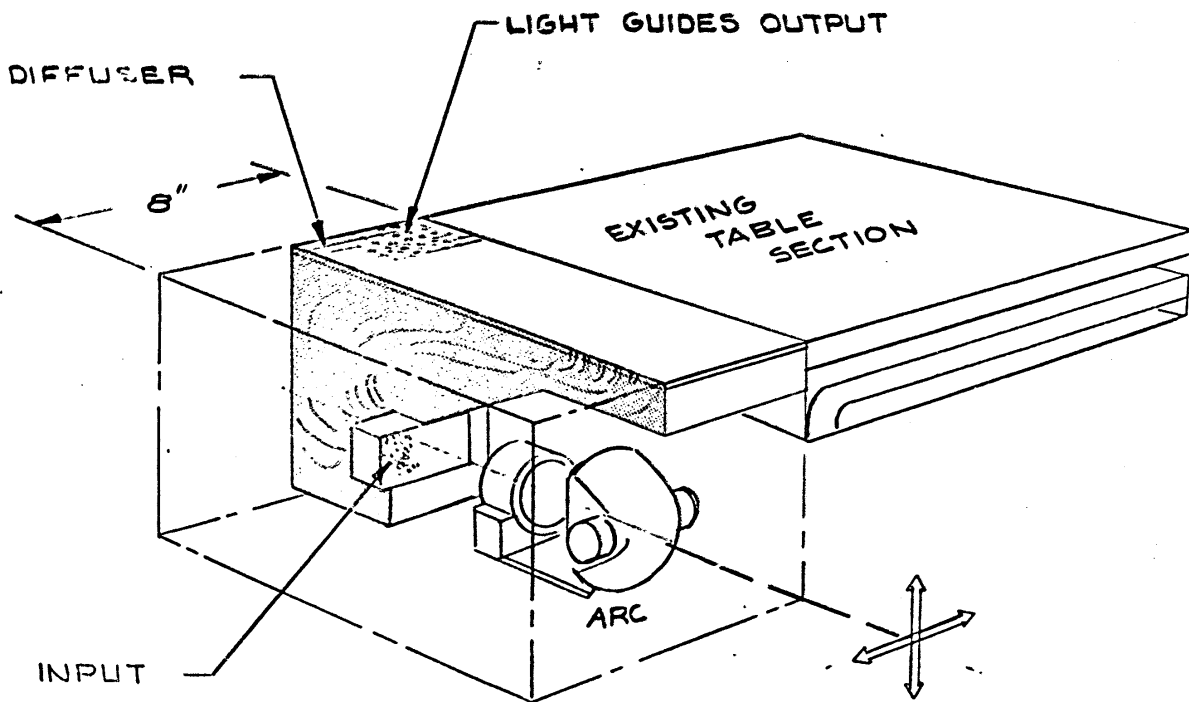
Note however that:

- A white blotter has about 0.8 reflection, so that correcting the measurement could lead to an output in excess of 20,000 ft. lamberts.
- A diffuser of higher gain than opal glass must be used.

This concept offers simplest attachment, low cost and possibly field retrofit. It may not achieve the 25,000 ft. lamberts intensity depending on eyepoint restriction.

3.6.3 Light Block Concept

Consider the entire light table region as a block of light guides for the output (Figure 11) in which the input is a compact version approximately $1/36$ the input area. Fixed light guides of plastic direct the incident irradiation from the input by any physical space available, to the viewing region which is slightly below the plane of the existing table top. The output guides are spaced to provide proper light flux overlap at the viewing surface.



A small arc can be focused to a small spot of concentrated light which can be servo controlled to any position of the viewing zone. When overall broad illumination is required the spot is defocussed and spread over the entire 8" x 15" viewing zone. In fact, it can be controlled to any size inbetween if desired.

The input can be placed in possibly 2 or 3 regions because of the flexibility of the light guides. There is no movement of these guides which remain fixed at all times so that no guides can be broken with usage.

Calculations indicate that the high luminance can be achieved in the local area. Since the ratio of the large zone to an approximate 3" x 3" small intense area is 12, an overall luminance of approximately 2000 ft. lamberts could be attained if the 25,000 ft. lamberts is available over the small area.

This technique does not alter performance or characteristics of the existing table. Only the conversion of luminous flux to heat at the film needs to be considered since the source is at a distance more accessible to heat dissipation. Horizontal masking can be incorporated at the input.

It is versatile because size of high intensity area can be increased or decreased continuously if desired.

Modification required is in the light tray well. The lamps must be shortened, and the present glass diffuser replaced by a higher gain section over the block.

This approach is subject to high cost of materials and is the major reason for exclusion from further consideration in this proposal. Production cost of light guides are not expected to drop significantly with increased quantities. Therefore a development of production techniques would be required.

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Enclosure 1

3.6.4 Partial Insert Concept

Consider an 8" x 2-3/4" left and right section of the zone raised as an add-on unit or partially inserted into the light tray and illuminated by projection in which only Y motion needs to track. A long tungsten halide source or an arc beam could be projected into the input of a light pack. A smaller 2-3/4" x 2-3/4" light pack could be substituted and needs to track in both X and Y direction and has the advantage in requiring less lumens input.

Since the basic lossless requirement at the output of a perfect diffuser corresponding to 25,000 ft. lambert desired luminance over the 2-3/4" local area is defined to be 1350 lumens at 5000°K, increasing the area to 8" x 2-3/4" requires a proportional increase to 3900 lumens input at the 8" light pack. Because of the projection losses in achieving the aspect ratio in the projected beam, considerable high input lamp power is necessary. If it is assumed a 10% projection efficiency attainable, the total flux available from a 5000°K lamp must be at least 39,000 lumens. The Marc 300 can provide a total of 25,000 to 30,000 lumens but utilization depends again on the height of light packs. A study of the subsystem illumination incorporating a source and matched collector projection optics is required to avoid excess power and increase projection efficiency in this limited case. This wide light pack approach is questionable. By substituting a 2-3/4" x 2-3/4" light pack the collection required is more reasonable since with a 10% projection efficiency the need would be for 13,500 total lumens which lies within the capability of the Marc 300 arc.

In all projection approaches the projected light beam must have reasonably uniform cross-section over a length of at least 12 inches. This projection approach is considered with the projection subsystem placed at the rear and on top of the table (other areas may be considered as pointed out in Figures 2 through 6). The constraints limit the use of some of these areas and no decision can be made until the full design of the optics and a lamp have been established. Some spaces for the projection optics could be:

- . In the electronics well at the rear of the light tray with one lamp removed.
- . Beneath the light tray.

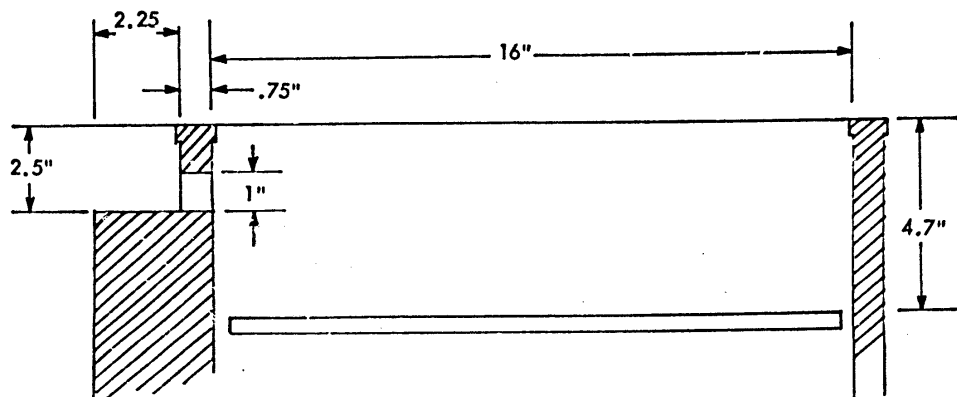
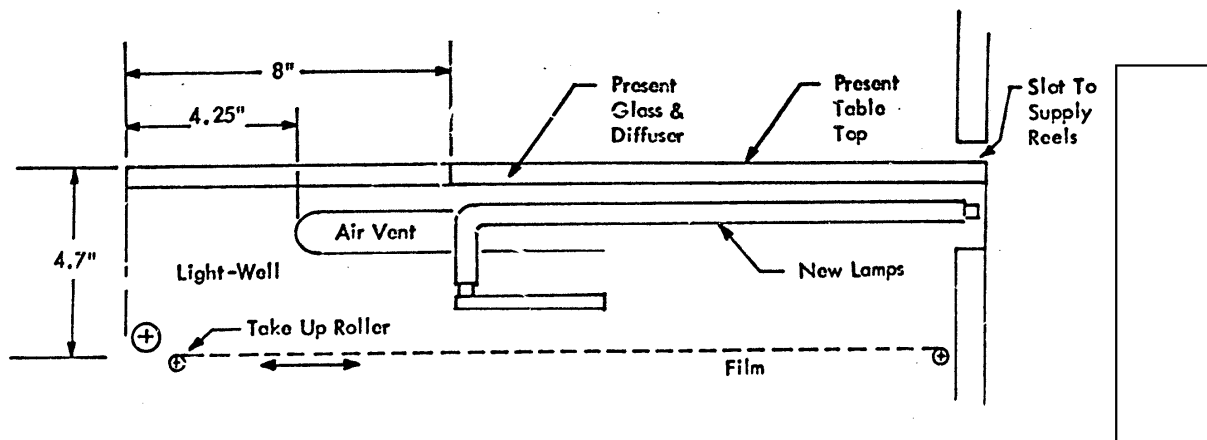
Light calculations presented earlier in Paragraph 3.6.2 are applicable here and indicate that 18,000 to 20,000 ft. lamberts is achievable depending upon light pack height and eyepoint.

A projection system in conjunction with a light pack avoids concentration of heat at the film, minimizes heat at the source since a more efficient luminous radiator is needed, heat dissipation is at a distance from the observer and minimizes discomfort, fan or blower vibrations are less apt to be transferred to the film plane. If this is a partial insert rather than strictly add-on the vibrations are better isolated and more space is made available.

This system does raise the eyepoint and introduces extra rollers in the film path to clear the slot to supply reels. If a partial insert, it requires modification to the viewing area with removal of existing glass and diffuser, and as an insert a small portion of the 15" length is reduced to project the light beam down. The long, or X dimension, of viewing area is reduced to accommodate rollers. A portion of the broad background light area is blocked while the 8" x 2-3/4" requires masking, but the 2-3/4 inch square does not.

3.6.5 Total Insert - Light-Well Concept

Consider a change in the table to accommodate a lamp integral with the light pack. The volume under the 8" x 15" zone of interest can be made available with modification (Figure 12). When the existing lamps are shortened by the 8" width, a well approximately 4-1/2" deep is available. Some loss in space occurs because of the lower take-up idling roller (Figure 4). In this system a tungsten source of approximately 200-300 watts can be introduced beneath the viewing area. There is some room available to image the lamp filament and to deflect the beam vertically by



reflection into the local area. Output measurement of the commercially available 200 ETL tungsten halide lamp was made to determine what could be expected. Luminance of 21,000 ft. lamberts was measured with a Spectra Spot meter using a frosted glass mixer in the beam and an opal glass diffuser at an illuminating distance producing a 3-1/2" diameter area. Although this tungsten has a 3200°K color temperature it does indicate values within a factor of 2 to 2-1/2 which may be achieved by a designed collector and a substitute high gain diffuser. The ETL is more accessible to dimming control either by mechanical means, or an Inconel gradient neutral filter, or by some form of reflector control because it converges the light into a small cross-section.

Heat dissipation and direction of flow are a possible problem, but space is less confining than that for add-on or partial insert. A small arc could be introduced if necessary to assure the color temperature since long path projection losses are avoided.

Broad background lighting needs to be modified by the use of lamps similar to those presently in the table. These would be installed along the 15" length of the 8" x 15" x 4-1/2" well. Mirror reflectors may be necessary to direct more light to the viewing diffusing surface.

This approach retains present viewing level, retains present threading, and avoids any surface mechanical movements and devices to interfere with viewing. It affects the original constraints by requiring a modification which shortens existing lamps and requires additional lamps and controls. Depending on the type of fluorescent lamps, it restricts the present masking control to a portion of the viewing area only, and does obscure some of the background light. Masking can be retained by modifying the shape of the existing lamps. It may require factory retrofit.

3.7 Selected Designs

Based on design studies to date, as exemplified by the data presented in the previous sections of this proposal, [] feels there are several possible designs which will achieve the goals of the Development Objective for a High Intensity Tracking Light Source. Four configurations have been selected for detailed presentation, each having its own attributes and drawbacks. These designs and their principal characteristics are summarized below.

Configuration #1 Add-On

- . 18,000 ft. lamberts potential
- . Eyepoint raised 1"
- . Limited microscope viewing at left and right ends (10")
- . 2 extra rollers each side - film thread path altered
- . Exposed light pack
- . Minimum table rework for attachment
- . No replacement of table components
- . Low potential production cost
- . Extra DC power supplies required
- . Some background light obscuration
- . Background light unchanged.

Configuration #2 Add-On

- . 24,000 ft. lamberts potential
- . Eyepoint raised 2"
- . Limited microscope viewing left and right ends (10")
- . 3 extra rollers each side
- . Exposed light pack
- . Minimum table rework for attachment

Configuration #2 Add-On (Continued)

- . No replacement of table components
- . Lower potential production cost
- . Extra DC power supplies required
- . Some background light obscuration
- . Background light unchanged
- . Film thread path altered.

Configuration #3 Partial Insert

- . 18,000 ft. lamberts potential
- . Eyepoint raised 1"
- . Limited microscope viewing at each end (5")
- . Limit rear (Y) of high intensity zone to 13-1/2"
- . 2 extra rollers - film thread path altered
- . Light pack enclosed and protected
- . Extra DC power supplies required
- . Background light unchanged
- . Some background light obscuration
- . Simple change in table components
- . Integral unit insert

Configuration #4 Total Insert

- . 25,000 ft. lamberts + potential
- . Retains eyepoint
- . Background light 2,000 ft. lamberts
- . Modification of light tray
- . Replacement of existing lamps
- . Table top unchanged
- . Limit rear (Y) of high intensity zone to 13-1/2".

The details of these designs are given in the following paragraphs. Separate work statements for each of the designs proposed are given in Section 4.0. Separate pricing data for each of the proposed designs is given in Enclosure 2.

3.7.1 Add-On Configuration #1

3.7.1.1 General Description - Figure 13 illustrates the add-on configuration which from the review of the earlier discussions has the following potential characteristics:

- . Simple field retrofit
- . Low estimated production cost
- . Some loss in table characteristics
 - . Table viewing area restricted on left and right sides
 - . Eyepoint slightly raised
 - . One extra roller
- . 18,000 ft. lambert high intensity potential

With reference to Figure 13, the proposed configuration consists of an arc to achieve the 5,000°K color requirement with a special formed collector and a compatible designed projection system to shape the beam into the 2-3/4 x 1" input aspect of the light pack. Excluding luminance transmission, the choice of light pack depends upon the ease of achieving an asymmetrical aspect ratio of approximately 3 to 1 to keep the eyepoint from being too high, i.e., within 1" of the existing table condition. X and y tracking both manual and synchronized automatic will be provided within the 8 x 15" viewing zone. Extra rollers are required to thread and drive the film over the 2-3/4" light pack position.

The effective microscope viewing zone is held to 8 x 15 inch in each of the viewing sections near the center. The balance is suitable primarily for visual non-microscope viewing purpose because of the altered film path. Because the roller

Use of this figure of personnel data is not to be made in connection with the 1960s program of the Department of Defense (DDC) 1960s

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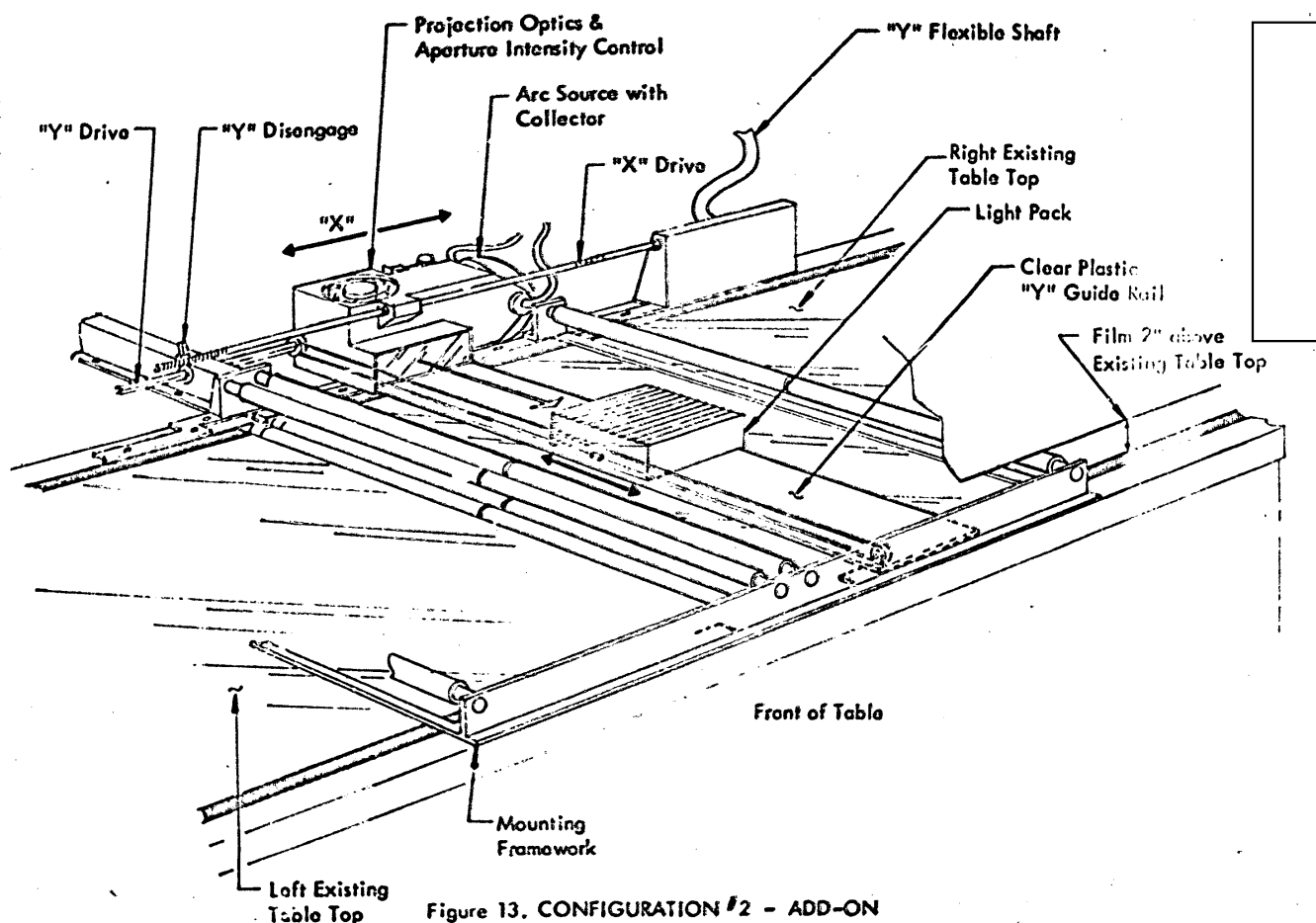


Figure 13. CONFIGURATION #2 - ADD-ON

and controls are easily visible on the table it presents a relatively low visual appeal. The x, y tracking drives are exposed and would be considered accessible to physical interference. A glass cover can be introduced but it raises the eyepoint further.

A diffuser is essential at the output of the light pack to assure the luminance fills the numerical apertures of the microscopes. It is not essential that it be a perfect lambertian type.

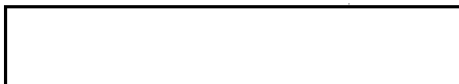
3.7.1.1.1 Illumination Sources - Two high intensity light sources will be provided, one for each viewing area of the table. Each one consists of a light pack that collects total flux from a projection system and directs it vertically into a light pack beneath the film. The light pack size will be 2-3/4" square and approximately 1" in height. These light packs will be individually controlled manually for adjustment beneath the rhomboid arms and then locked into place beneath the rhomboids in order to track with the carriage motions, retaining the initial alignment.

3.7.1.1.2 Illumination Level - Each of the high intensity light sources will provide approximately 18,000 ft. lamberts measured at the viewing surface of the light pack with the specially configured Weston ft. lambert meter specified. The minimum levels of the high intensity sources will be approximately 1,500 ft. lamberts or 500 ft. lamberts less than the background light level. The light source level control will be a continuously variable iris and there will be logarithmic control effective in the lower levels.

Calculations were made in paragraph 3.6.2 for a projection system which used the Marc 300 arc, a magnification of $\times 2$ to fit the projection distance of approximately 12", and a projection lens of 1" diameter at f/3. The illumination incident at a light guide pack was 1.25×10^3 lumens/sq. inch from the 5,000°K source. This yielded a luminance of 18,000 ft. lamberts at the output of the light guide pack through a high gain diffuser. Achieving this value depends on the computability between the light pack, projection system, light source collector and space available.

Broad background illumination will remain unchanged.

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3.7.1.1.3 Color - Color temperature of 5,000°K at all luminance levels will be achieved by either use of an arc directly or converting the light flux by filtering. The color rendering index is to be 70.

3.7.1.1.4 Uniformity - The variation in level of brightness across the surface of the high intensity source will not exceed 20%.

3.7.1.1.5 Heat - Since this configuration is an add-on to the table, the temperature of the glass viewing surfaces of the attachment will not be more than 20°F above the viewing surface of the existing light table.

3.7.1.1.6 Illumination Controls - Controls will be provided for independently varying the intensity of the illumination. There will be an OFF switch for each light source located in a convenient place so as not to disturb the present human engineering of the light table.

3.7.1.2 Configuration

3.7.1.2.1 General - Both of the light sources each 2-3/4" x 2-3/4" will be independently adjustable beneath the objective lenses of the rhomboid arms or beneath a single objective of the zoom 240 stereoscopic system in the mono viewing mode. The light sources will hold their position when the optics carriage mount is tilted 15° from the horizontal. In this add-on configuration the light sources will be retrofitted to the

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 1540 light table as an attachment to the top of the existing viewing area. For this add-on system the eyepoint height will be raised approximately 1" above the original design of the table. This is considered within the limits of a significant change.

3.7.1.2.2 Size - The entire system of light sources and tracking mechanism will remain within the confines of the maximum dimensions of the light table under all operating conditions.

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3.7.1.2.3 Control - Adjustment of the position of the light sources under the optics will be achieved by electro-mechanical means. A servo system will operate from potentiometers which will indicate the position of the bridge in its path across the zone of interest. This will drive dc motors which in turn will operate the cables to the light pack in both the x and y direction. There will be switches in order to disengage the two light sources and make them independent. There will also be a biasing control to permit independent adjustment of the light sources manually. For protection and avoiding damage to the system there will be an override control which will prevent the light packs to be driven beyond their limits.

3.7.1.3. General - The construction of this equipment will be such as to meet the highest commercial standards of construction.

3.7.1.3.1 Maintenance - It will be directed towards ease of maintenance and convenient access to internal portions to allow for replacement of light sources and to make other adjustments if necessary.

3.7.1.3.2 Safety - All safety precautions will apply. Provisions will be made to prevent personnel from coming into contact with electrical circuitry and also to keep the external temperatures in the vicinity of the light source well below dangerous temperatures. The moving parts at the top and rear of the table will be covered to shield the lamp and to prevent inadvertent accidents by the operator. Provisions will be made to insure that the light pack source will be incapable of moving in the Y direction in an uncontrolled manner because of the tilt to the table. A safety disconnect will be incorporated to turn off the lamp should the blower fail.

3.7.1.3.3 Power - The equipment will operate from 117 volts $\pm$ 15 volts, 60 Hz single phase alternating current. A special power supply will be provided to operate the DC arc. The input to this power supply is identical as to the balance of the equipment of the light table.

3.7.1.3.4 Collimation - The light pack will track on the horizontal plane of the existing light table and will run parallel to the stereoscopic mount within 15 mils over the 9 x 15 inch zone of interest.

3.7.1.3.5 Finish - The best finish essential to reduced specular glare and similar to the balance of the existing light table will be used on all visible surfaces.

3.7.2 Add-On Configuration #2

3.7.2.1 General Description - This configuration is essentially the same as illustrated in Figure 13 except that the height of the add-on configuration will take up the full clearance allowable between the top of the present viewing table surface and the bottom of the microscope mounting carriage. It raises the eyepoint approximately 2" above the present table. Such an arrangement offers a reduction in production cost as it simplifies the nature of the light pack. Two rollers are required at each end to bring the film through the slot to the supply spools. Other characteristics and descriptions related to configuration #1 are applicable here. There is the difference that the light pack can be altered from a 3:1 aspect ratio to a 3:2 aspect ratio and thus offers the opportunity to use a diffuse light pack in place of an optical guide pack to fill the microscope numerical aperture. Configuration #2 has the following potentials and characteristics.

- . Simple field retrofit
- . Lowest estimated production cost
- . Some loss in table characteristics
 - . Table viewing area restricted on left and right ends
 - . Two extra rollers required
 - . Eyepoint raised 2" (maximum)
- . 25,000 ft. lamberts high intensity potential

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The system can be described as follows: the light from an arc will be projected into a beam similar to configuration #1 but having approximately 3:2 ratio cross section in place of the 3:1 for configuration #1. The projected beam enters the input of the diffuse light pack and the total lumens will be diffused over a lambertian distribution at the output area beneath the film. The anticipated brightness is based on the previous calculations for a projection system of configuration #1 and is calculated below.

3.7.2.1.1 Illumination Sources - Two high intensity sources will be provided, one for each viewing area of the table. Each consists of a light pack that collects the total flux from a projection system and directs it into a diffused light pack. The light pack will be 2-3/4" x 2-3/4" square by approximately 1-3/4" in height. These light packs will be individually controlled manually for adjustment beneath the rhomboid arms and then locked into place in order to track the microscope carriage motion retaining alignment with the rhomboid objectives.

3.7.2.1.2 Illumination Level - The illumination level will be approximately 25,000 ft. lamberts measured at the viewing surface of the light pack with the specially configured Weston ft. lambert meter. Minimum levels of the high intensity source will be approximately 1,500 ft. lamberts or 500 ft. lamberts less than the broad area background light level. The light source intensity level will be continuously variable and there will be a logarithmic control effect at lower light levels.

Calculations extended from configuration #1 and applied to the larger light pack are made herein. Previous calculations for an f/3, 1" diameter lens, 1" diameter incident input at the light pack and 3x magnification for the Marc 300 arc resulted in 1.25×10^3 lumens/sq. inch illumination at the light pack.

In this second configuration the height of the pack is increased to slightly less than 2" for clearing the microscope carriage. Therefore the magnification

4.0 STATEMENT OF WORK

A separate Statement of Work is presented below for each of the four configurations.

4.1 Statement of Work for Configuration #1, Add-on. (Reference Section 3.7.1).

4.1.1 Study

A study will be conducted of several areas which have been raised in the discussions on potential concepts.

Optical system collector and projection techniques and packaging will be examined to transmit a light beam from an arc at the rear of the table into a light pack compatible with the lamp and the goal of exceeding the anticipated 18,000 ft. lamberts luminance. Means will be studied to direct a beam of light into the light pack at 2 aspect ratios. One is the 3:1 aspect ratio and the other is for symmetrical beams with varied diameters with resulting effect on eyepoint height. A search will be made of vendors to determine the best techniques to obtain a formed collector either of metal or glass compatible with the intent of mass production as well as being specifically useful in removing heat. Optical consulting will be subcontracted.

Light packs of different types will be examined. Four types of light packs for the add-on approach will be considered. The light pack with the 3:1 aspect ratio, 3:2 aspect ratio, the light guide pack with the 1-inch beam input, and the diffusing light pack will be analyzed for their compatibility and optimization with the available and suitable optical systems. Effect of increasing eye point height (or pack height) on brightness will be shown.

Cable and mechanical means of linking the motor drives to the light pack will be examined for least obstruction of the existing light or the viewing area as well as the suitability for adjustment and placement on the top of the table. Mechanical drives and electric drive motors will be surveyed to determine which approaches might be most suitable. Both Selsyn or dc servo system approaches will be reviewed.

The removal of heat from the arc itself as well as an examination of heat dissipation at the film will be examined carefully; in particular, the quantity of air required and the path necessary through the table to avoid effecting the electronics and create discomfort to the operator.

Various lamps and arcs will be reviewed in light of their aspect ratios, their color temperature, heat dissipation required and lumens available to achieve the brightness necessary compatible with the projection technique evolved. Some of the

lamps and arcs considered are tungsten-halide with built-in reflectors, the Marc 300 arc lamp, Xenon arc and possibly Mercury arcs such as the UA2 whose color rendition is quite low but would need to be corrected if sufficient lumens could be made available. Possibility of dimming the arc output by electric power input control will be examined before mechanical or optical devices will be chosen.

The results of this study will be suitably compiled with trade offs indicated for presentation to the contractor at a predesign review.

Technique for possibly automatically limiting the luminance blast that an operator may encounter when film density drops from 2.0 to 0.3 during scanning will be examined.

4.1.2 Design

The design phase will commence following clarification of the tasks and direction at the predesign review. This will include the design of the optical projection system, the selected light pack, the design of the electrical circuitry for the servo mechanism and the packaging suitable for the light table with human engineering aspect particularly in mind. Optical design will be subcontracted.

4.1.3 Fabrication

Fabrication of optical components will be subcontracted. Mechanical fabrication will commence as soon as design drawings are available.

4.1.4 Assembly and Installation

Subsystems will be assembled and checked out. The entire unit will be attached to the GFE light table and properly adjusted for operation and delivery.

4.1.5 Acceptance Test

A preliminary acceptance test will be conducted at the contractor's facility, with final acceptance testing at the sponsor's facility.

4.1.6 Reports

Monthly interim reports will be submitted during the period of the contract in accordance with Specification No. DB-1001. Three copies of each will be provided.

A final report will be submitted in accordance with DB-1001 upon completion of the program. Three copies will be provided.

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4.1.7 Instruction Manual

An instruction manual describing installation, operation and maintenance of the light source will be supplied in accordance with good commercial practice.

4.2 Statement of Work for Configuration #2, Add-on. (Reference Section 3.7.2).

4.2.1 Study

Optical system collector and projection techniques will be examined with the maximum height light pack considered to achieve the goal of 25,000 ft. lamberts at the viewing area. The 3:2 aspect ratio of the light pack and a compatible beam cross-section will be studied. A review of vendors will be made to determine best approach to a wide angle collector at the lamp or arc. Formed glass or metal collectors will be examined for heat dissipation. Optical consultant will be used.

In particular, two light packs will be studied; the lambertian diffuser, and the light guide pack with a symmetrical beam input required. Effect of increased eye-point to 2-inches on the operator will be checked.

Cable and mechanical means of linking the motor drives to the light pack will be examined for least obstruction of the existing light on the viewing area as well as the suitability for adjustment and placement on the top of the table. Mechanical drives and electric drive motors will be surveyed to determine which approaches might be most suitable. Both Selsyn or dc servo system approaches will be reviewed.

The removal of heat from the arc or lamp itself as well as an examination of heat dissipation at the film will be examined carefully; in particular, the quantity of air required and the path necessary through the table to avoid effecting the electronics and create discomfort to the operator.

Various lamps and arcs will be reviewed in light of their aspect ratios, their color temperature, heat dissipation required and lumens available to achieve the brightness necessary, compatible with the projection technique evolved. Some of these to be considered are tungsten-halide with built-in reflectors, the Marc 300 arc lamp, Xenon arc lamp and possibly Mercury arcs like the UA2 whose color rendition is quite low but would need to be corrected if sufficient lumens could be made available. The possibility of dimming the arcs by electric input power control will be examined before mechanical or optical means will be chosen.

The results of this study will be suitably compiled with trade offs indicated for presentation to the contractor at a predesign review.

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Technique for possibly automatically limiting the luminance blast that an operator may encounter when film density drops from 2.0 to 0.3 during scanning will be examined.

4.2.2 Design

The design phase will commence following clarification of the tasks and direction at the predesign review. This will include the design of the optical projection system, the selected light pack, the design of the electrical circuitry for the servo mechanism and the packaging suitable for the light table with human engineering aspect particularly in mind. Optical design will be subcontracted.

4.2.3 Fabrication

Fabrication of optical components will be subcontracted. Mechanical fabrication will commence as soon as design drawings are available.

4.2.4 Assembly and Installation

Subsystems will be assembled and checked out. The entire unit will be attached to the GFE light table and properly adjusted for operation and delivery.

4.2.5 Acceptance Test

A preliminary acceptance test will be conducted at the contractor's facility, with final acceptance testing at the sponsor's facility.

4.2.6 Reports

Monthly interim reports will be submitted during the period of the contract in accordance with Specification No. DB-1001. Three copies of each will be provided.

A final report will be submitted in accordance with DB-1001 upon completion of the program. Three copies will be provided.

4.2.7 Instruction Manual

An instruction manual describing installation, operation and maintenance of the light source will be supplied in accordance with good commercial practice.

4.3 Statement of Work for Configuration #3 - Partial Insert (Reference Section 3.7.3)

4.3.1 Study

The effect on background light of displacing the diffuser from its present location to the raised position will be examined and the implication on the type of

light pack that can be suitably employed. For example, if a light guide pack is used then a diffuser must be either a part of the pack or the diffuser can be the one selected for the entire table top. However, one approach may cause inefficient use of space and interfere with light levels to be achieved, the other approach means that a higher gain diffuser than the present opal glass must be considered.

Optical system collector and projection techniques and packaging will be examined to transmit a light beam from an arc at the rear of the light tray into a light pack compatible with the arc or lamp and the goal of exceeding the anticipated 18,000 ft. lambert intensity. Means will be studied to direct a beam of light into the light pack at 2 aspect ratios. One is the 3:1 aspect ratio and the other is for symmetrical beams with varied diameters and effect on eyepoint height. A search will be made of vendors to determine the best techniques to obtain a formed collector either of metal or glass compatible with the intent of mass production as well as being specifically useful in removing heat. Optical consulting will be subcontracted.

Light packs of different natures will be examined. Four types of light packs for the add-on approach will be considered. The light pack with the 3:1 aspect ratio, 3:2 aspect ratio, the light guide pack with the 1-inch beam input, and the diffusing light pack will be analyzed for their compatibility and optimization with the available and suitable optical design systems. Effect of increasing eyepoint height (or pack height) on brightness will be studied and shown.

Cable and mechanical means of linking the motor drives to the light pack will be examined for least obstruction of the existing light on the viewing area as well as the suitability for adjustment and placement on the top of the table. Mechanical devices and electric drive motors will be surveyed to determine which approaches might be most suitable. Both Selsyn or dc servo system approaches will be reviewed.

The removal of heat from the arc or lamp itself as well as an examination of heat dissipation at the film will be examined carefully; in particular, the quantity of air required and the path necessary through the table to avoid effecting the electronics and create discomfort to the operator.

Various lamps and arcs will be reviewed in light of their aspect ratios, their color temperature, heat dissipation required and lumens available to achieve the brightness necessary, compatible with the projection technique evolved. Some of these

to be considered are tungsten-halide with built-in reflectors, the Marc 300 arc lamp, Xenon arc lamp and possibly Mercury arcs like the UA2 whose color rendition is quite low but would need to be corrected if sufficient lumens could be made available. The possibility of dimming the arcs by electric input power control will be examined before mechanical or optical means will be chosen.

The results of this study will be suitably compiled with trade offs indicated for presentation to the contractor at a predesign review.

Technique for possibly automatically limiting the luminance blast that an operator may encounter when film density drops from 2.0 to 0.3 during scanning.

4.3.2 Design

The design phase will commence following clarification of the tasks and direction at the predesign review. This will include the design of the optical projection system, the selected light pack, the design of the electrical circuitry for the servo mechanism and the packaging suitable for the light table with human engineering aspect particularly in mind. Optical design will be subcontracted.

4.3.3 Fabrication

Fabrication of optical components will be subcontracted. Mechanical fabrication will commence as soon as design drawings are available.

4.3.4 Assembly and Installation

Subsystems will be assembled and checked out. The entire unit will be attached to the GFE light table and properly adjusted for operation and delivery.

4.3.5 Acceptance Test

A preliminary acceptance test will be conducted at the contractor's facility, with final acceptance testing at the sponsor's facility.

4.3.6 Reports

Monthly interim reports will be submitted during the period of the contract in accordance with Specification No. DB-1001. Three copies of each will be provided.

A final report will be submitted in accordance with DB-1001 upon completion of the program. Three copies will be provided.

4.3.7 Instruction Manual

An instruction manual describing installation, operation and maintenance of the light source will be supplied in accordance with good commercial practice.

4.4 Statement of Work for Configuration #4 - Total Insert (Reference Section 3.7.4)

4.4.1 Study

Optical and components study of the high intensity light source for this particular application will be made. Two means of implementation will be examined.

- a. Lamp or arc integral with light pack.
- b. Light beam projected across the lamps.

Uniformity control by either a mixer and or collector design will be examined. Evaluation will be made for the Marc 300, a suitable Xenon arc, and the tungsten-halogen. A means of light control for the light pack by either neutral density or varying reflection will be examined for compactness, dynamic range and resistance to heat. Light output by varying input electric power will be examined before optical or mechanical means is chosen.

Possible use of a light guide pack for compactness in place of a mirror will be examined to minimize any loss of high intensity viewing zone of interest. In this case the means for best light collection, 2-3/4-inch diameter beam projection and baffling will be studied. A search will be made of vendors to determine the best techniques to obtain a formed collector either of metal or glass compatible with the intent of mass production as well as being specifically useful in removing heat. Optical consulting will be subcontracted.

Evaluating the best mean of retaining the broad background lighting by:

- Shortening original lamps and adding fluorescent lamps to the well or,
- Dropping and extending present fluorescent lamps into the well.

Packaging and folding of the light pack and rearranging the extended fluorescent lamps will be examined to retain masking capability and to raise and lower the tray if necessary, in changing from broad area viewing to high intensity source viewing.

Cable and mechanical means of linking the motor drives to the light pack will be examined for least obstruction of the existing light over the broad 8-inch X 15-inch viewing area. Mechanical drives and electric drive motors will be surveyed

to determine which approaches might be most suitable. Both Selsyn or dc servo system approaches will be reviewed.

The removal of heat from the light source itself as well as an examination of heat dissipation at the diffuser and film will be examined carefully. In particular, the quantity of air required and the path necessary through the table to avoid effecting the electronics and create discomfort to the operator. At the film the possibility of supplying a small air flow from a tube attached to the rhomboids appears practical as a means of controlling film temperature.

Various arcs and lamps will be reviewed in light of their color temperature, heat dissipation required and lumens available to achieve the brightness necessary since a larger variety is possible for this configuration. Some of these to be considered are tungsten-halide with built-in reflectors, the Marc 300 arc lamp, Xenon arc lamp and possibly Mercury arcs like the UA2 whose color rendition is quite low but would need to be corrected if sufficient lumens could be made available with low heat output.

The results of this study will be suitably compiled with trade offs indicated for presentation to the contractor at a predesign review.

Technique for possibly automatically limiting the luminance blast that an operator may encounter when film density drops from 2.0 to 0.3 during scanning will be examined.

4.4.2 Design

The design phase will commence following clarification of the tasks and direction at the predesign review. This will include the design of the optical projection system, the selected light pack, the design of the electrical circuitry for the servo mechanism and the packaging suitable for the light table with human engineering aspect particularly in mind. Optical design will be subcontracted. In particular, new fluorescent lamp design will be included if necessary.

4.4.3 Fabrication

Fabrication of optical components will be subcontracted. Mechanical fabrication will commence as soon as design drawings are available.

4.4.4 Assembly and Installation

Subsystems will be assembled and checked out. The entire unit will be attached to the GFE light table and properly adjusted for operation and delivery.

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4.4.5 Acceptance Test

A preliminary acceptance test will be conducted at the contractor's facility, with final acceptance testing at the sponsor's facility.

4.4.6 Reports

Monthly interim reports will be submitted during the period of the contract in accordance with Specification No. DB-1001. Three copies of each will be provided.

4.4.7 Instruction Manual

An instruction manual describing installation, operation and maintenance of the light source will be supplied in accordance with good commercial practice.

5.0 DELIVERABLE ITEMS

25X4 [] proposes to deliver the following items for any configuration chosen as part of the contract.

5.1 Instruction Manual

An instruction manual describing installation, operation and maintenance of the light sources will be prepared and submitted in accordance with good commercial practice.

5.2 Reports

Each month interim reports (3 copies) will be submitted to reach the Government Sponsor not later than the first business day after the 15th of the month following the reporting period in accordance with paragraph 2.2.1, Monthly Reports, of Specification No. DB-1001.

A final report (3 copies) will be submitted on or before the 30th day following completion of the work on the contract in accordance with paragraph 2.2.2, Final Report, of Specification No. DB-1001.

5.3 Equipment

A functional prototype high intensity light source mounted in or on a 1540 light table will be delivered. The 1540 light table Government-furnished item will be modified to demonstrate the prototype light source with final acceptance testing performed at the sponsor's facility.

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6.0 SCHEDULE

Two schedules are proposed by [] the first for Configuration 1 and 2, the second for Configuration 3 and 4. Adherence to either schedule requires Government-furnished equipment as set forth in Section 7 and shown in Figures 18 and 19.

6.1 Schedule for Configurations 1 and 2

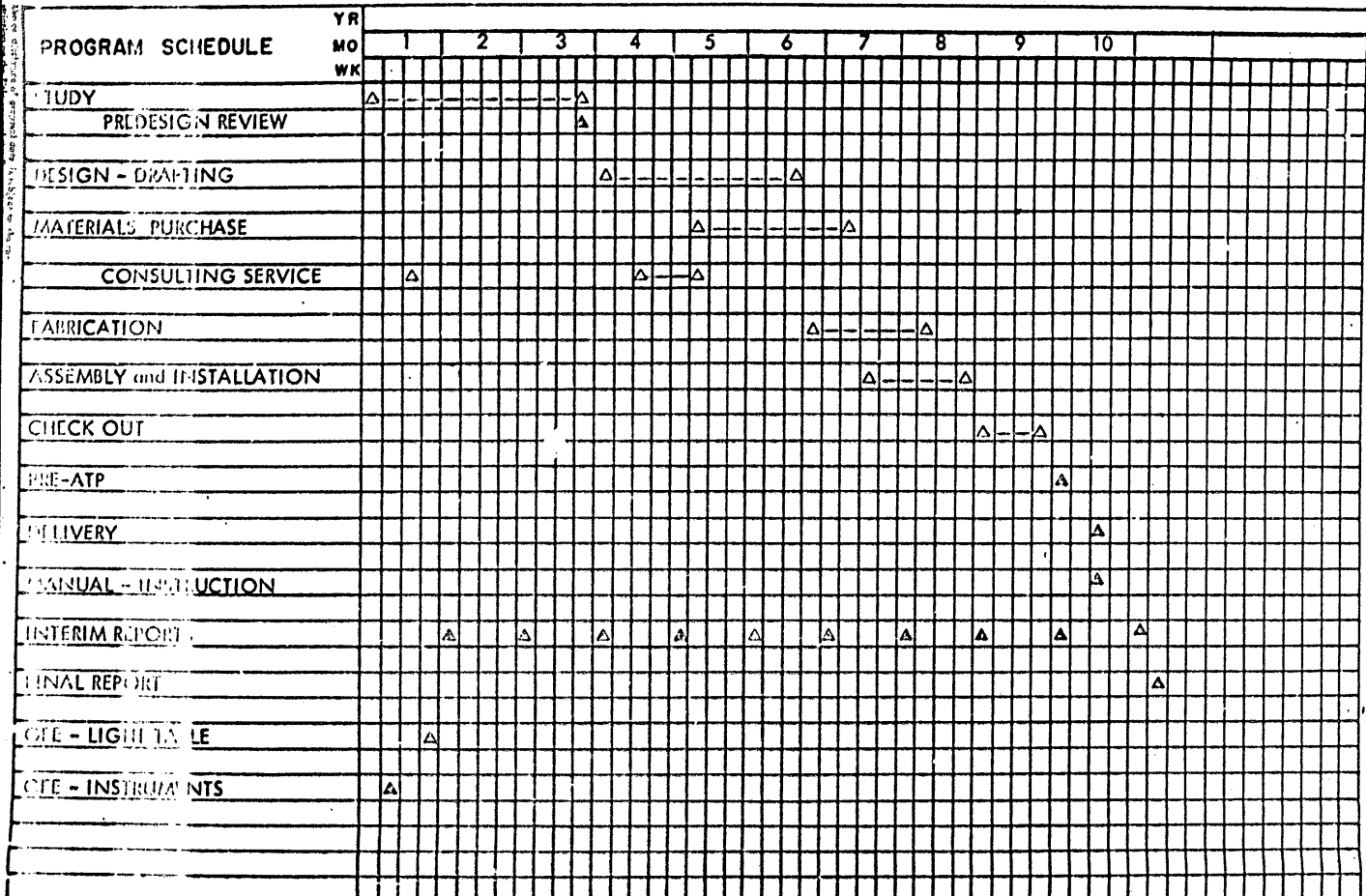
[] proposes to complete the design, fabrication and installation of a High Intensity Tracking Light Source within a ten (10) month period. A preliminary design review will be held with appropriate Government representatives approximately three (3) months after the start of the program. Figure 18 shows the schedule for the major events applicable to both configurations.

6.2 Schedule for Configurations 3 and 4

[] proposes to complete the design, fabrication and installation of a High Intensity Tracking Light Source within a twelve (12) month period. A preliminary design review will be held approximately 3-1/2 months after the start of the program. Figure 19 shows the schedule for the major events applicable to both configurations.

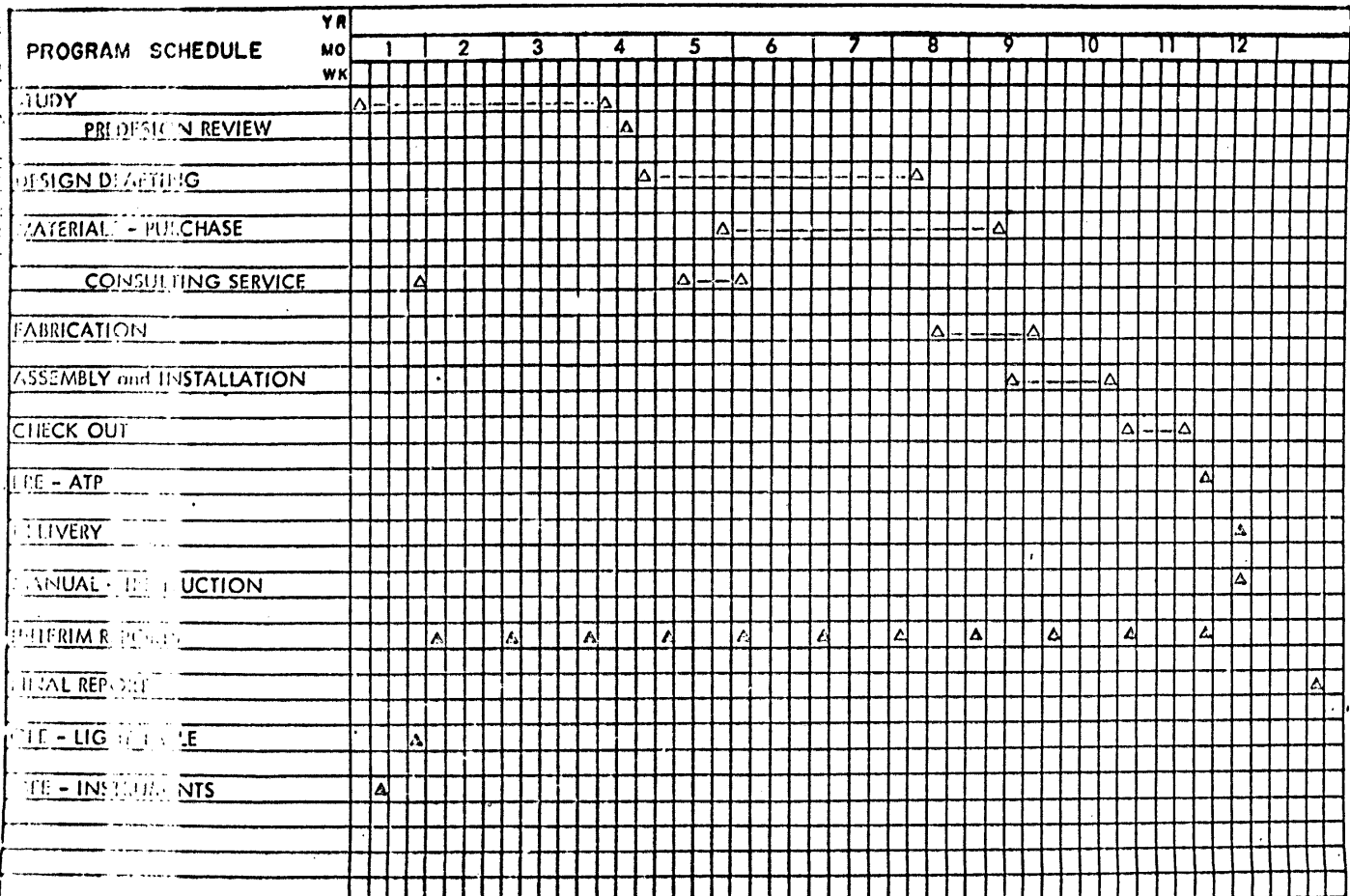
HIGH INTENSITY TRACKING LIGHT SOURCE

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HIGH INTENSITY TRACKING LIGHT SOURCE

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7.0 GOVERNMENT-FURNISHED EQUIPMENT (GFE)

Government-furnished equipment itemized below is to be supplied to the contractor in accordance with the Schedule, Section 6.0.

7.1 Light Table

A Government-furnished light table, [] MLT 1540 Light Table, will be provided no later than thirty (30) days from initiation of contract.

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7.2 Instruments

- a. A specially configured Weston Foot Lambert Meter will be Government-furnished no later than thirty (30) days from initiation of contract and for duration of the contract.
- b. A Gamma Scientific Scanning Spectroradiometer, Model #3000 with special fiber optics probe will be Government-furnished no later than fourteen (14) days after initiation of contract.
- c. The accepted method of measuring the color rendering index with the Gamma Scientific Spectroradiometer will be Government-furnished no later than fourteen (14) days after initiation of contract.

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TEST AND EVALUATION REPORT
IMAGE DEFINITION DEVICE
T&E REPORT 71-01

TEST and EVALUATION REPORT

Technical Operations, Incorporated

IMAGE DEFINITION DIVISION

MARCH 1971

TGE Report No. 71-01


Test & Evaluation Branch
Engineering Support Division
Technical Services Group

National Photographic Interpretation Center

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ABSTRACT

The Image Definition Device (IDD) was tested against NPIC's requirements for a High Intensity Tracking Light Source (HITLS). It was concluded that neither the tracking system nor source of illumination were compatible with the light table or optical system specified for the HITLS.

25X1 This report contains details of a testing program performed on a prototype device. The tests performed were restricted to: (1) those relating to changes in the [] 940 Light Table and [] Zoom 240R Stereoscope system; (2) the adaptability of the tracking mechanism to a split format configuration, and (3) the ability of the illuminators to provide the intensity necessary for the high magnification levels of the Advanced Stereo Rhomboids in the monoscope mode of operation. The results of these tests should aid in the development of the HITLS.

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1. INTRODUCTION

1.1 General

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The Image Definition Device (IDD) is a dual beam high intensity light source which tracks the rhomboid arms of a [] Zoom 240R Microstereoscope system. The device has been installed on a modified [] 940 Light Table by [] The contract was sponsored by Rome Air Development Center (RADC) in an attempt to enhance the contrast and therefore increase interpretability of photographic imagery. RADC performed engineering tests and operational evaluation to assure that the IDD conformed to the contractual requirements.

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After testing was completed at RADC, the IDD was offered to NPIC for evaluation. RADC requested that ESD/TIB perform the evaluation. The specifications of the High Intensity Tracking Light Source (HITLS), as stated in its Development Objective, were to be used as a guideline for compliance with NPIC needs. It was understood from the beginning that the IDD would not meet all specifications but that the information obtained would aid in development of the HITLS. After arrival at NPIC on 23 November 1970, the equipment was inspected for damage. ESD/EPB cleaned the equipment and made necessary minor repairs. The engineering tests were started on 7 December 1970 and completed on 31 December 1970.

An operational evaluation was not scheduled but Special Activities Division (SPAD) requested that they be allowed one day (5 January 1971) to perform their evaluation. Comments from their evaluation have been included in this report.

Upon completion of the testing program, the IDD was turned over to logistics (3 February 1971) for crating and shipment back to RADC.

1.2 Background

The development of the HITLS was brought about because of the low transmission characteristics of advanced optical

systems. It was felt that by increasing the illuminating power of the light source a sufficient amount of light would be available for imagery interpretation. As optical systems become more sophisticated, the need for light sources capable of providing illumination for them will become even more acute.

Large area illumination sources over 3000 footlamberts (fL) result in heat problems, wasted light and inefficient operation. It is desirable to confine the high-intensity illumination to a small area which fills the numerical aperture of the associated optical system. In order to retain maneuverability, it is then necessary for the high-intensity area to track the optical system. The IIR has most of those features described in the Development Objective of the HILLS (i.e., High-intensity, tracking light ability) and is of interest to NPIC for study purposes.

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4. DESCRIPTION OF EQUIPMENT

4.1 General

25X1 The Image Definition Device (IDD) consists of a [] 240R microstereoscope system mounted on a [] 940 Light Table. The light table has been modified by lowering the diffuser and background sources approximately 4.5 inches from their former position and adding a clear glass viewing stage. Two arms, containing an auxiliary illumination system and capable of tracking the rhomboid arms of the Zoom 240R are mounted between the diffuser and the clear glass film stage. This auxiliary illumination system consists of a light source and optical system which produces a controlled, high intensity, uniform beam of light.

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4.2 Mechanical

The tracking mechanism is attached to the [] Light Table at the back of the microscope carriage assembly. A beam extends into the light box and supports the weight of the auxiliary light sources. These sources have been pivoted directly below the pivot point of the rhomboid arms of the 240R microstereoscope system. A belt and pulley system positions the high intensity lights under the objectives of the rhomboid arms. Physical restraints have been put on the focus control mechanism which limits the use of objectives to 1X and 2X. The auxiliary light sources are not available for use in the binocular monoscopic mode.

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4.3 High Intensity Light Sources

The high intensity light sources provide well-controlled, uniform illumination. The intensity, numerical aperture (N.A.) and field stop of the sources are adjustable. The N.A. and field stop are individually controllable. The intensity control adjusts both sources simultaneously. The N.A. varies between 0.018 and 0.080. The field stop varies the illuminated area at the surface of the film stage from 0.18 inches to 1.20 inches.

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The intensity of the light sources is adjustable in two overlapping ranges. Each light source is powered by a single 12 Volt AC tungsten filament bulb. The color temperature of the system, measured at the surface of the viewing stage, corresponds to that of a tungsten light source.

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5. TEST DETAILS

5.1 Performance Tests

Requirements given below are excerpts from "Development Objectives High Intensity Tracking Light Source." The Image Definition Device was not manufactured to these requirements, therefore a statement of compliance will not be made concerning the specific requirement. The requirements will, however, be used as a guideline in determining whether or not the IDD will be capable, with minor alterations, of fulfilling the needs of NPIC.

5.1.1 Illumination Level of High Intensity Sources

Requirements: The maximum level of illumination will be at least 25,000 fl at the surface of the glass viewing stage. The minimum level will be 1,500 fl. The illumination will be continuously variable between maximum and minimum in a single continuous range or two overlapping ranges. Controls will be logarithmic with the slower response at the lower illumination levels. The two illumination sources will be individually adjustable. With one of the two sources set at maximum illumination level, there will not be a change of more than 500 fl in illumination level while the other source is adjusted through its full range.

Results: Due to the nature of the illumination it is impossible to measure brightness at the surface of the light table. Brightness, measured in foot-lamberts, is a unit of luminance applicable only to a perfectly diffusing surface. The IDD light source is a condenser system with a variable numerical aperture. In order to obtain a relative value of illuminating power, it was necessary to make measurements at a common point in the light path and compare the flux radiated by the IDD light source to a Lambertian distribution light source. The most convenient point to obtain the comparison was at the eyepieces of the Zoom 240R microscope.

An illuminating power equal in magnitude to that supplied by a 67,000 fl. light source was measured at the left eyepiece. An illuminating power equal in magnitude to that supplied by a 32,000 fl. light source was measured at the right eyepiece. These values are only applicable to this specific optical system and are not intended to represent an absolute or relative measure of illuminating power for other optical systems.

Both sources are continuously adjustable but not individually adjustable in two overlapping stages. The control is not logarithmic but the control motion is adequate to obtain any specified level of illumination. Figure 2 represents the illumination level of both left and right sources in both high and low intensity ranges vs. position of control knob. Data for each source has been normalized to read 100% of its maximum intensity.

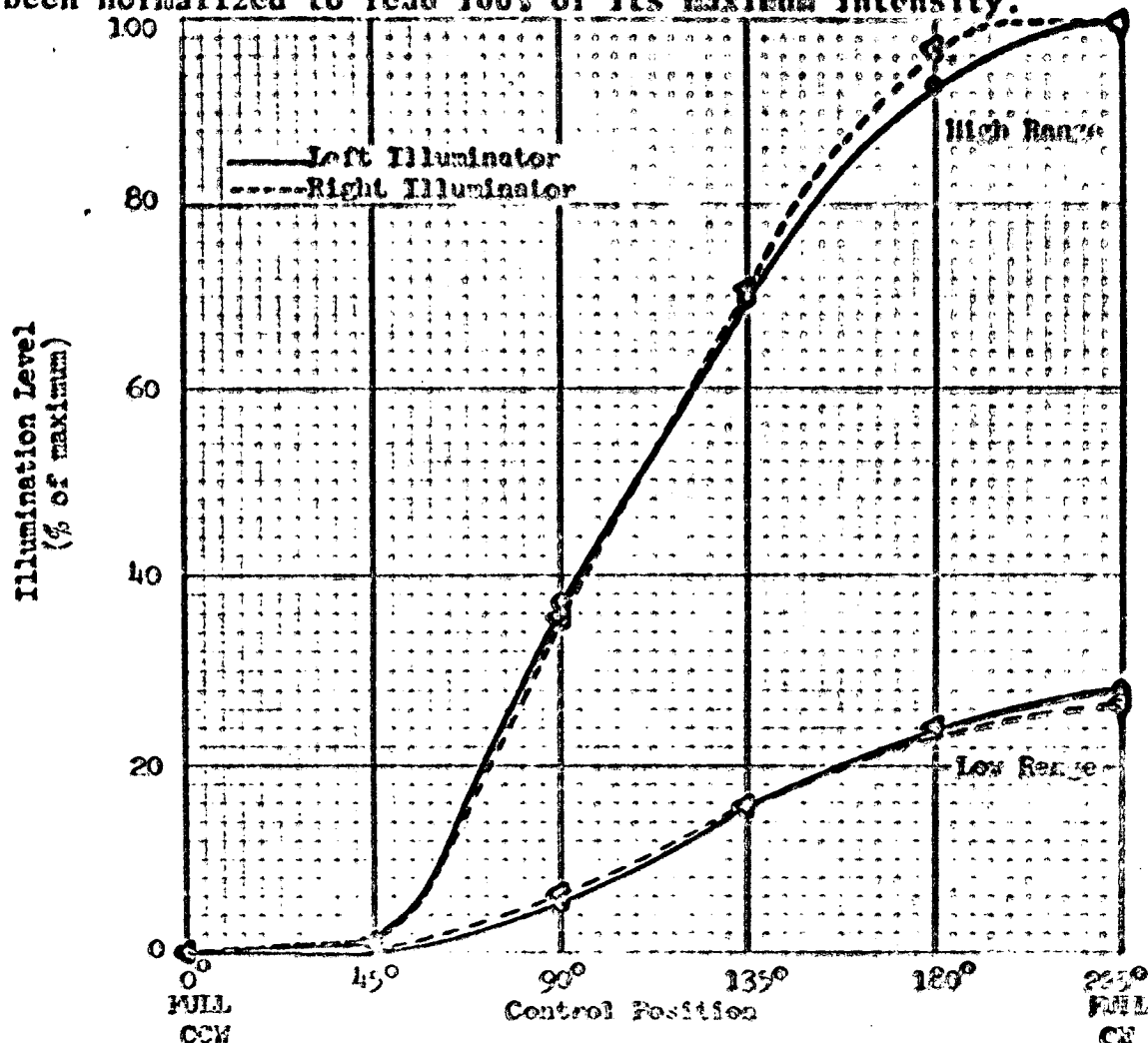


Figure 2: Illumination Vs. Control Position - Illumination expressed as a percent of maximum for each illuminator.

Test Procedures: A Gerni Scientific Inc. Model 2020 photometer and photopic filter were used to measure illumination at the eyepieces of a Zoom 240R stereomicroscope with Model "28" Rhinhold and 1X objectives attached. The fiber optics probe received all the flux at the exit pupil. A 1.0 density film was placed on the film stage. Readings were taken with this system positioned over a 3000 fL diffuse source. The same system was then placed over the 100 light source and measurements taken. The reading obtained at the left eyepiece from the left 100 source was 22.3 times greater than that from the 3000 fL source. Therefore, we have assumed that a 67,000 fL source would yield the same illumination at the left eyepiece as does the 100. In like manner the right 100 source yielded a reading equivalent to what would be expected from a 32,000 fL diffuse source.

5.1.2 Advanced Stereo Rhinhold (ASR)

Requirements: For the purpose of this report there are no requirements for performance of the ASR. The data taken was interpreted in an informative sense and listed as capabilities of the 100 in conjunction with the ASR. A comparison with results in the ASR T&E Report No. 70-02 will demonstrate the system's capabilities.

Results: The 100 increased the amount of light available at the eyepiece of the Zoom 240 and ASR system at all magnifications tested. The amount of increase was not constant throughout the range of magnifications due to a variation in numerical aperture (N.A.) with magnification change. Table 1 lists (in percentages) the light available at the eyepiece of the system when powered by the 100 (0.080 N.A.) compared to the light available at the eyepieces of a Zoom 240 pod alone with a 3000 fL light source.

Table 2 is a condensed version of the ASR's "Light Transmission Range," which was presented in T&E Report No. 70-02. A direct correlation can be drawn between the percent transmission and the light available at the eyepiece when illuminated by a 3000 fL source. A comparison between Table 1 and Table 2 shows as much as a 20 times increase at the lowest magnification levels to as little as a 1.9 times increase of the highest magnification levels.

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Table 1

100 Illumination Level
 (5 illuminating power available at eyepiece of
 Zoom 240 & ASR with the 100 light source compared
 to a Zoom 240 pod alone with a 3000 ft light source)

Objectives	1X		2X		3X	
	.7X	3X	.7X	3X	.7X	3X
Zoom Setting						
left eyepiece**	408	182	391	66	262	37
Stereo Mode						
right eyepiece*	178	133	179	54	170	28
left eyepiece**	192	91	185	37	128	21
Mono left						
right eyepiece**	206	109	203	43	141	24
left eyepiece*	112	76	123	28	109	16
Mono Right						
right eyepiece*	104	64	97	27	88	16

*Represents illumination levels taken with right illuminator at maximum intensity.

**Represents illumination levels taken with left illuminator at maximum intensity.

Note that the left illuminator has over twice the power of right illuminator (See Section 3.1.1). Zoom settings of .7X and 3.0X relative to the ASR with the 100 corresponds to .7X and 3.0X zoom settings for the pod alone.

Table 2

ASR Light Transmission Range* (%)

Objectives		1X		2X		3X	
		.7X	3.0X	.7X	3.0X	.7X	3.0X
Lambertian	Mono	---	11.6	11.5	10.8	11.1	8.4
Light Source	Stereo	20.2	20.2	20.4	18.8	20.1	14.8

*Condensed from ASR T&E Report No. 70-02

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Test Procedures: The ASR was mounted on a Zoom 240 stereoscope and the rhomboid arms adjusted such that its optical axis was coincident with the center of the illuminated area. A 1.0 neutral density film was placed on the format to simulate operational conditions. The intensity was measured with the calibrated Gamma 2020 at the eyepiece. A Photopic filter was used.

5.1.3 Background Illumination Gradient

Requirements: The background illumination will be capable of a light intensity range of 200 fL to 2000 fL and will otherwise retain the same characteristics as the replaced light source. The brightness gradient will not exceed 15% between any two measurements taken within the restricted area.

Results: The range in illumination measured at the center of format was 190 fL to 2200 fL. The brightness gradient varied from 37% to 55% as shown in the table below. The highest intensity was found in the center of format and decreased steadily to the corners of the format. Table 3 shows the percent variation at various intensities.

Table 3

Background Illumination Gradient

Range	High Value	Low Value	%Variation
Maximum Intensity High Range	2200 fL	1300 fL	41%
Minimum Intensity High Range	330 fL	150 fL	55%
Maximum Intensity Low Range	910 fL	570 fL	37%
Minimum Intensity Low Range	190 fL	95 fL	50%

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Test Procedures: The surface was marked off into 39 square sectors (3 deep and 13 wide) and bounded by a one inch border. A Weston 759 footlambert meter was used to measure the brightness at the geometric center of each sector.

5.1.4 Color Temperature

Requirements: Broad-band white illumination is required with a color temperature of 5000K $\pm$ 500K at all luminance levels. Chromaticity aim points of X=0.345 and Y=0.358, and a color rendering index of 70 or higher is required.

Results: The light sources are powered by two 12 Volt AC tungsten filament bulbs. The results were those expected from this source. The table below shows the results of both left and right sources at two different intensity levels.

Table 4

	Color Temperature			
	Rt. Max. Intensity		Lft. Max. Intensity	
	High Range	Low Range	High Range	Low Range
Color Temperature	2913 K	2610 K	2865 K	2571 K
Chromaticity X	.4482	.4706	.4527	.4745
Coordinates Y	.4164	.4178	.4188	.4192
Color Rendering Index	94.61	96.60	93.98	95.57

Test Procedure: Measurements were taken at the surface of the light table with a Gamma Scientific Inc. Model 3000 Spectroradiometer. The tracking mechanism had been removed to allow the sensor to sample the light at the center of the light beam.

5.1.5 Temperature

Requirements: The temperature of the glass viewing surface or external surface of the light source will not exceed 100°F or 30°F over ambient, whichever is higher.

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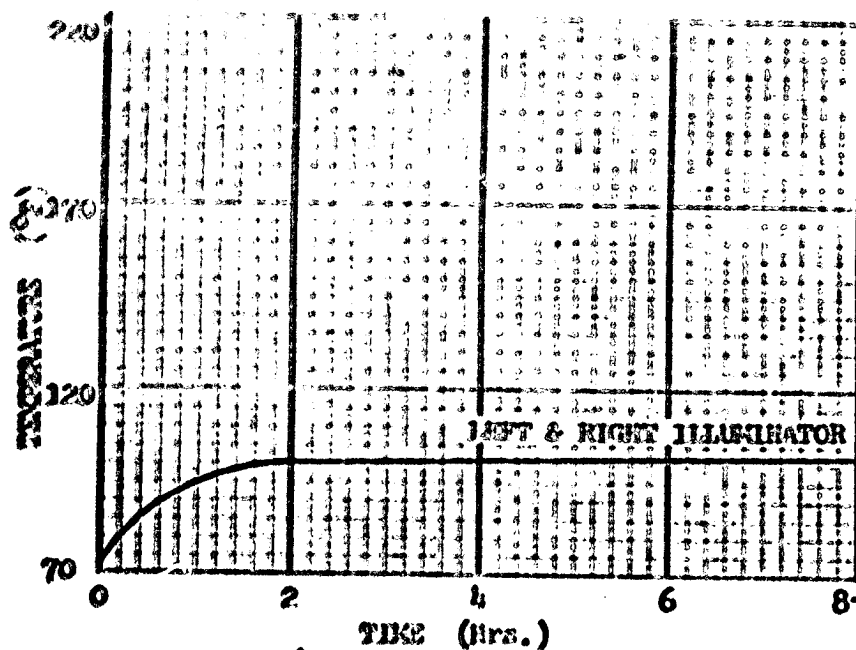


Figure 4: Temperature vs. Time between 2.0 density film and film stage with background illumination off.

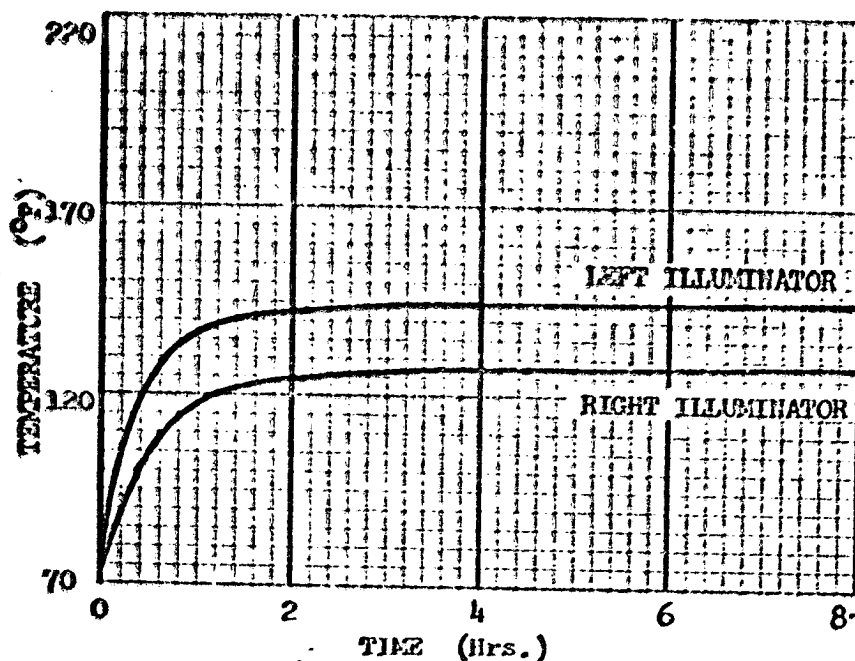


Figure 5: Temperature vs. Time at film stage over heat shield.

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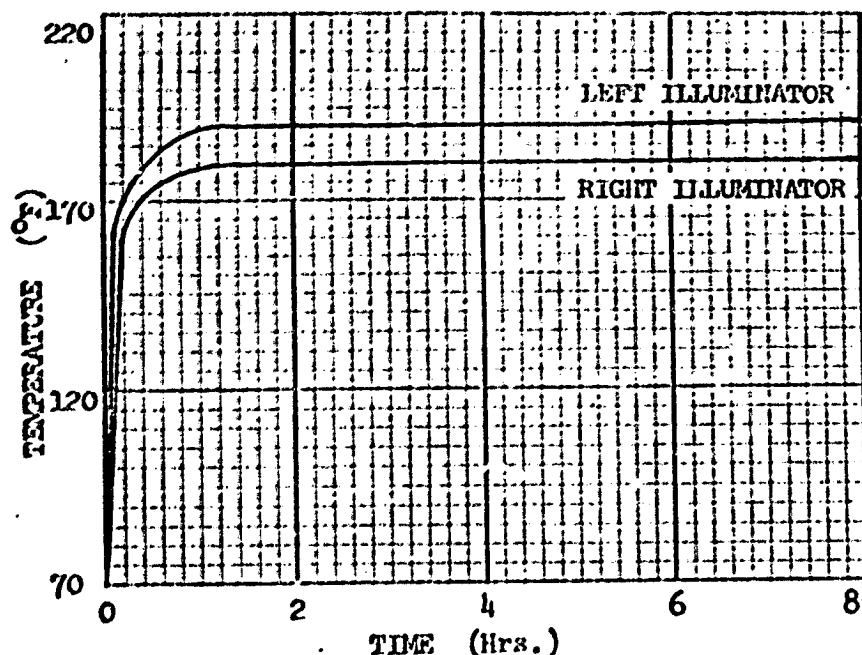


Figure 6: Temperature vs. Time on heat shield surface.

Test Procedure: The surface of the light table was covered with a 2.0 density film and illuminators set at maximum output, to simulate worst case conditions. Temperature was measured with thermistor probes placed between the film and glass viewing stage.

5.2 Engineering Analysis and Evaluation

5.2.1 Tracking Mechanism

The tracking mechanism is of simple design and construction. The light sources follow the rhomboid arms rigidly. However, the design would be unacceptable for a double format, take-up loop configuration. The physical restriction of the take-up loop slot and center opening would restrict the motion of the pod and pod support to movement in the y direction. This would limit the x direction coverage to the arc of the rhomboid arm.

The high intensity tracking light arms collide with the walls of the light well. This keeps the optical axis of the microscope as much as 1.0 inch from the edge of the usable viewing area in the y direction. When the collision is violent the tracking light source is knocked

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out of alignment. Evidence of this can be seen in previous damage to one of the tracking belts. Other than the limits imposed on format coverage the tracking mechanism does not adversely affect carriage motion.

5.2.2 Advanced Stereo Rhomboid (ASR)

The tracking mechanism is suited to the ASR in both mono and stereo modes of operation. The ASR utilizes the rhomboid arm and objectives in its mono mode of operation. Therefore, it is not necessary for the tracking system to be able to adjust itself to a third objective position for monoscopic viewing.

5.2.3 Human Engineering

The level of illumination is of sufficient magnitude to be dangerous to the eye at full intensity. A warning to this effect has been placed on the instrument. There are safety devices to protect against this hazard, but none have been implemented on this prototype. Other sources of hazard to the operator are the heat shields for the lamps. The controls for field and aperture stop are immediately adjacent to the heat shields, which reach temperatures of 192°F.

5.3 Operational Evaluation

Although an operational evaluation was not planned for this prototype, one operational component (SPAD) did express a desire to test the device under operating conditions. Although no new information was revealed during these tests they did reiterate some items noted during engineering tests. These deficiencies were (1) lack of mono mode of operation and (2) danger of eye damage due to high intensity light. SPAD expressed a desire for a table with high intensity capabilities for viewing excessively high density film. For their requirements, a single table would be sufficient.

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